

REPORT No. WP 119

COMMERCIAL IN CONFIDENCE

E/5A/CON/1551

E/5A/CON/1574

# **EXTRACTION OF POWER FROM SEA WAVES**

## **INTERIM REPORT – 1979**

### **DRAWINGS**

**Wavepower Limited**

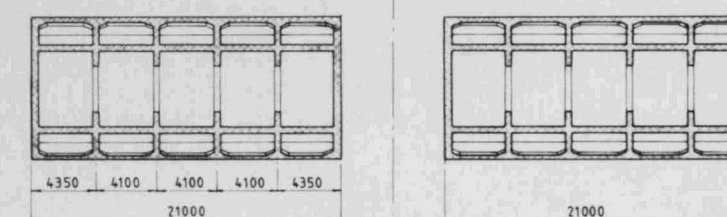
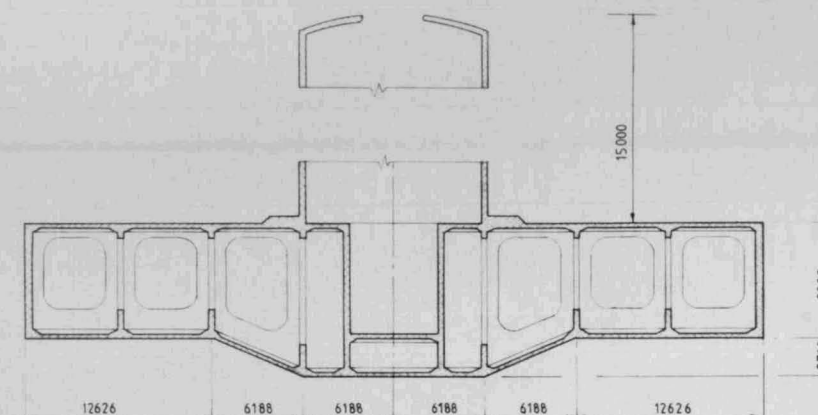
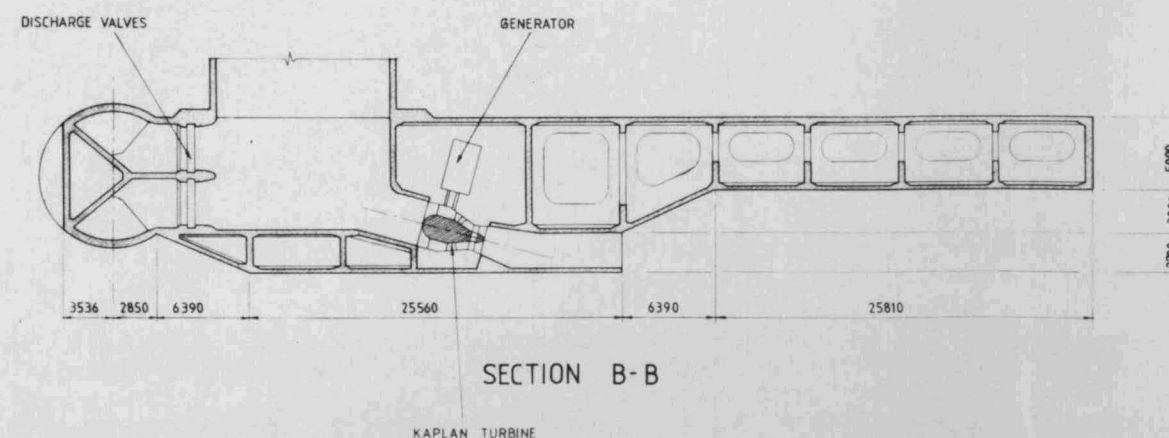
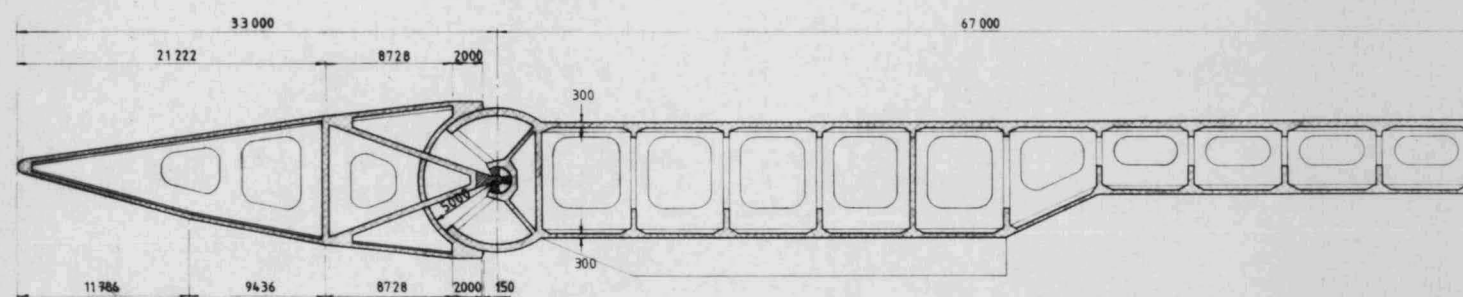
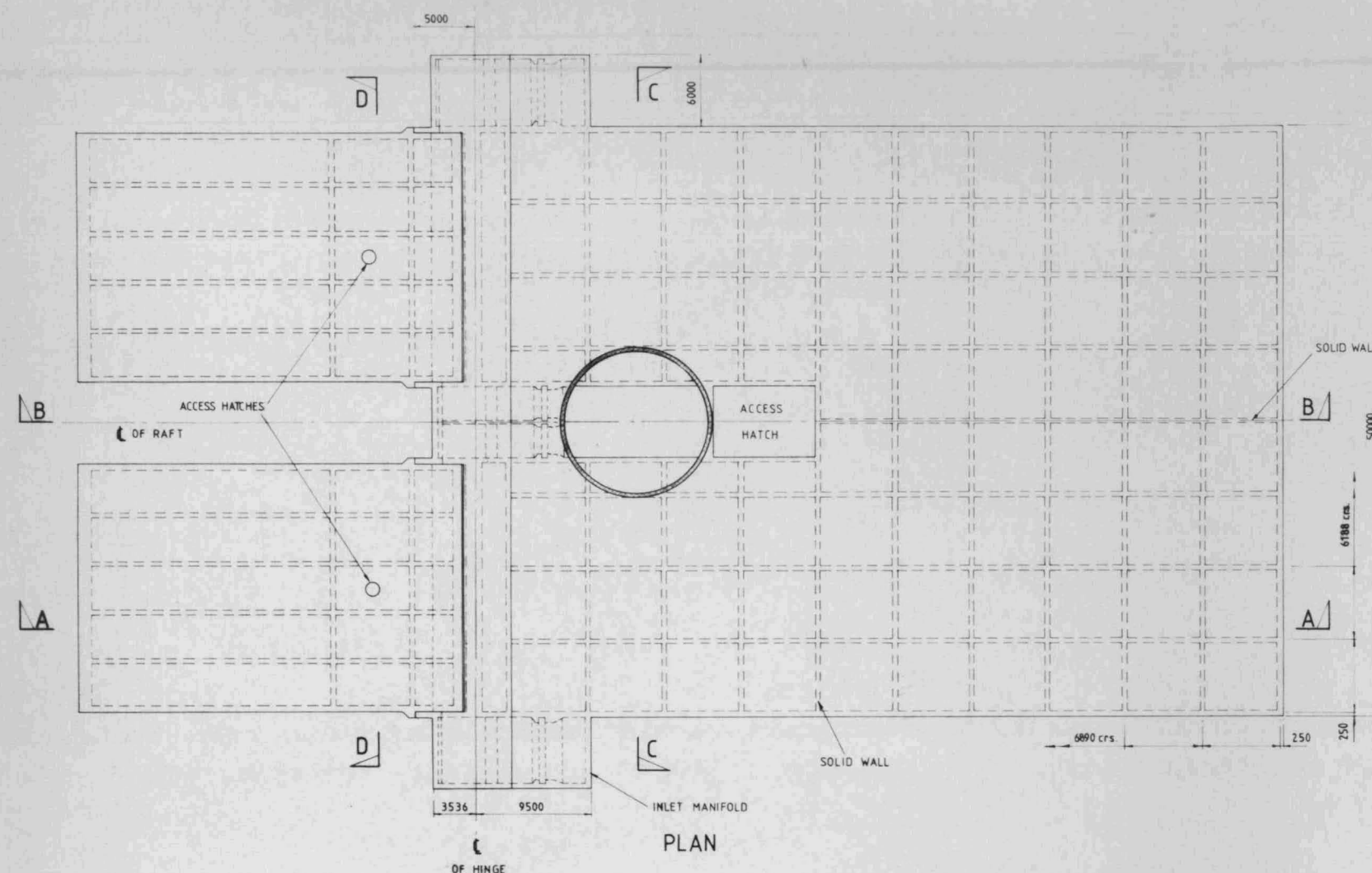


Consulting Engineers GIFFORD AND PARTNERS

DECEMBER 1979



NOTES



LOW PRESSURE  
CROSS FLOW VANE  
PUMP WITH KAPLAN  
TURBINE

GENERAL  
ARRANGEMENT  
OF CONCRETE HULL

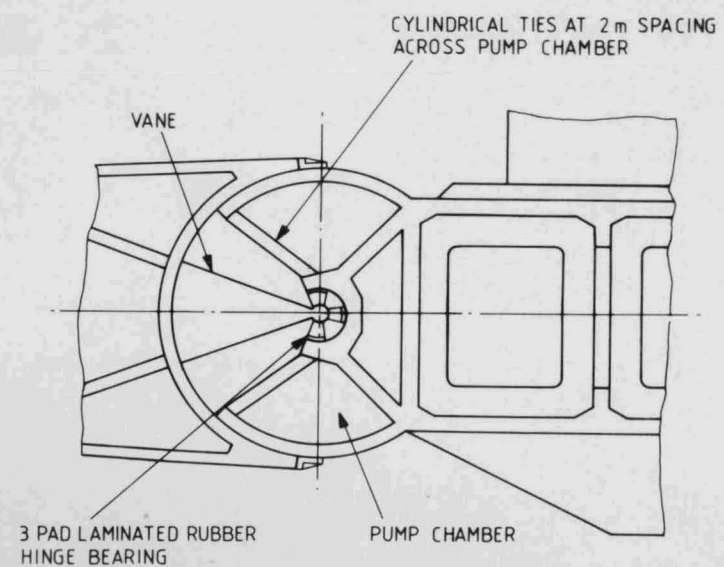
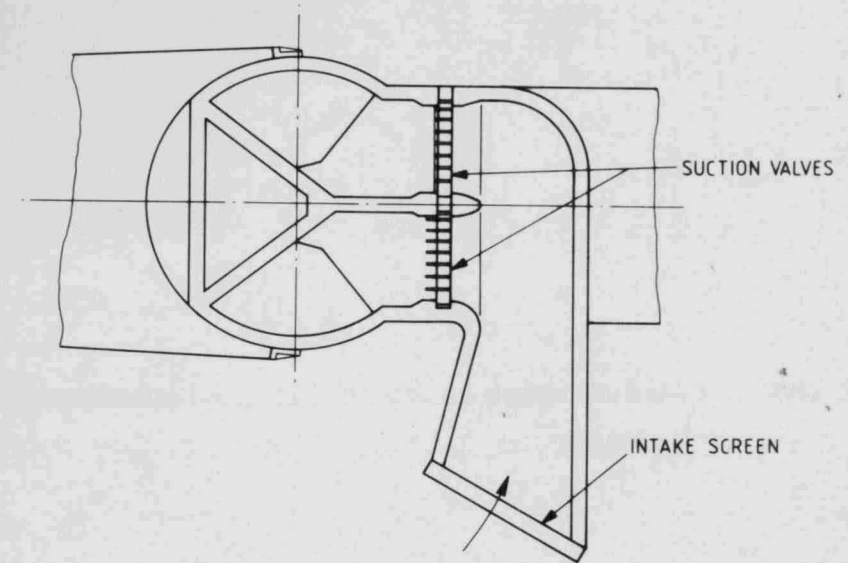
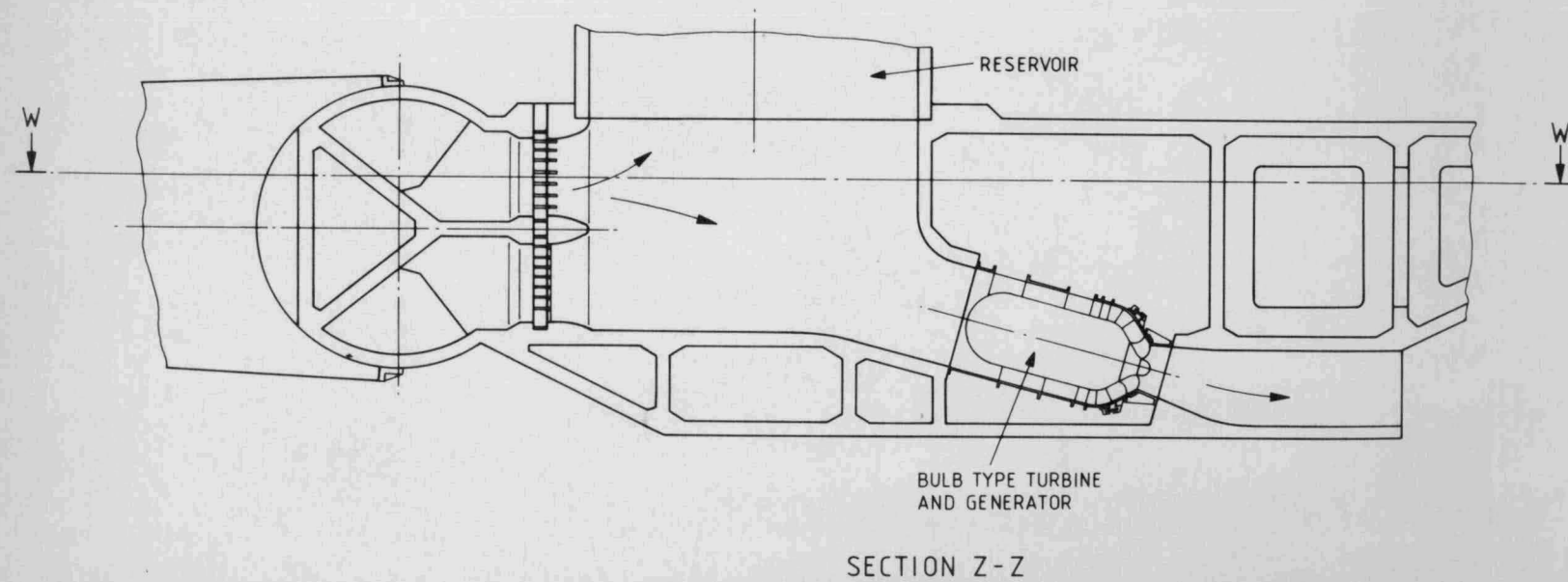
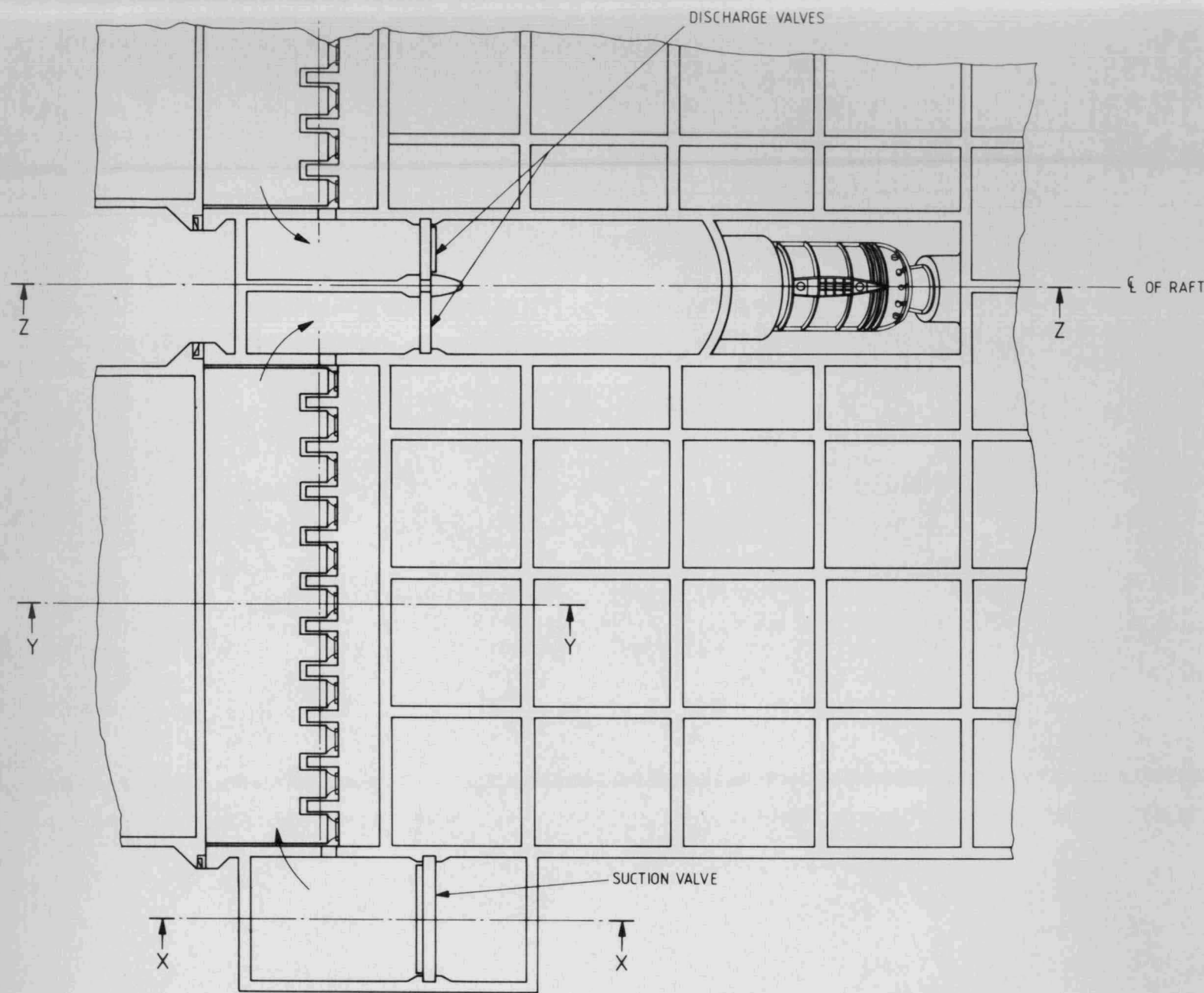
**WAVEPOWER LIMITED**

Carlton House Ringwood Road  
Woodlands Southampton SO4 2HT  
Telephone Cadnam (042-127) 3473

1:200

2519-909

2591-909



2519 - 905

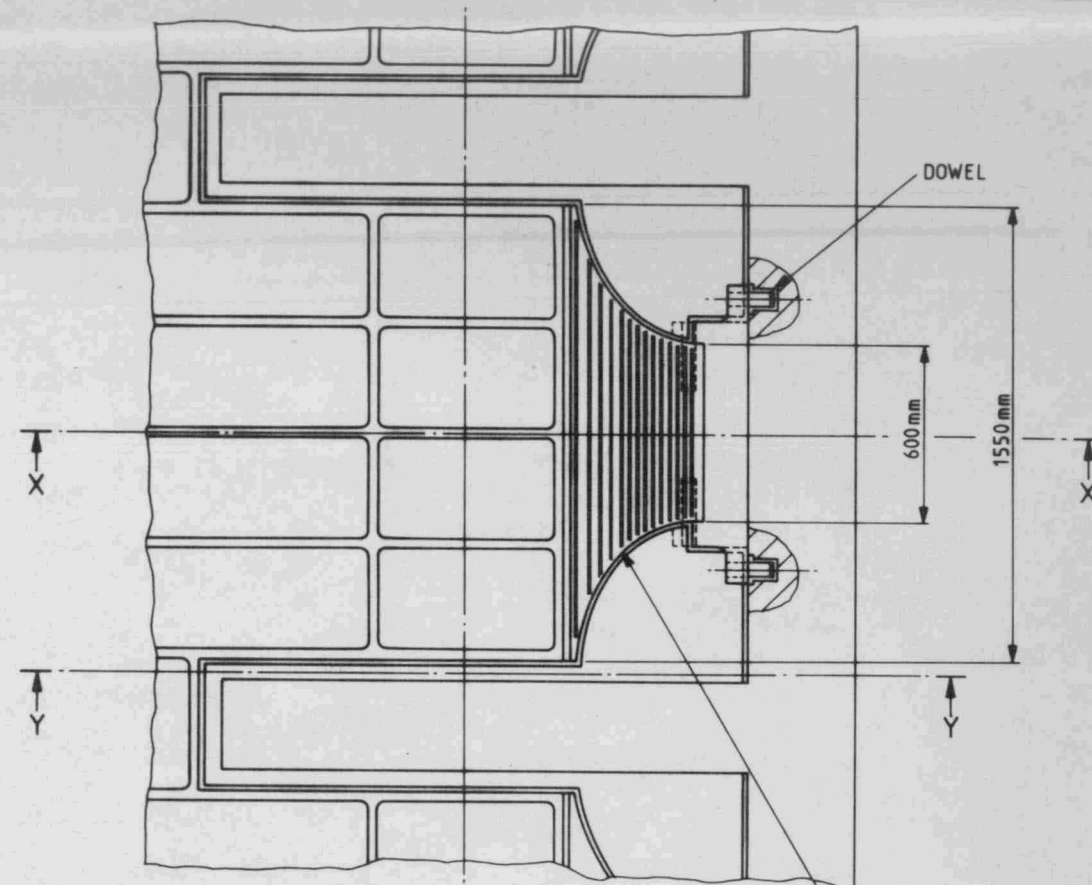
LOW PRESSURE  
HYDRO SCHEME  
WITH VANE PUMP  
FOR ON BOARD  
GENERATION

**WAVEPOWER LIMITED**  
Carlton House, Ringwood Road,  
Woodlands, Southampton, SO4 2HT  
Telephone: Cadman 042 1271 5471

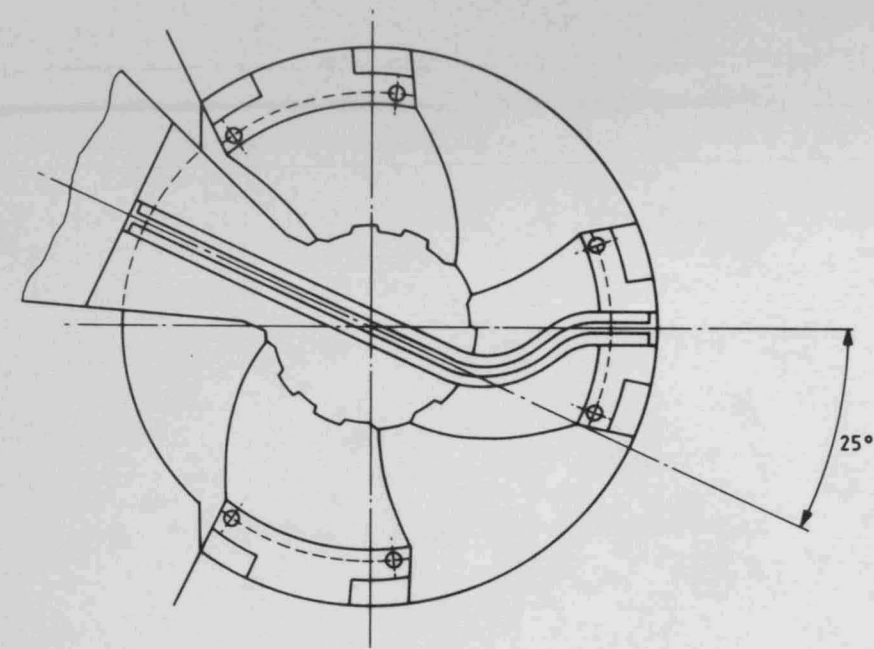
LTS  
27-11-79 1:100

2519 - 905

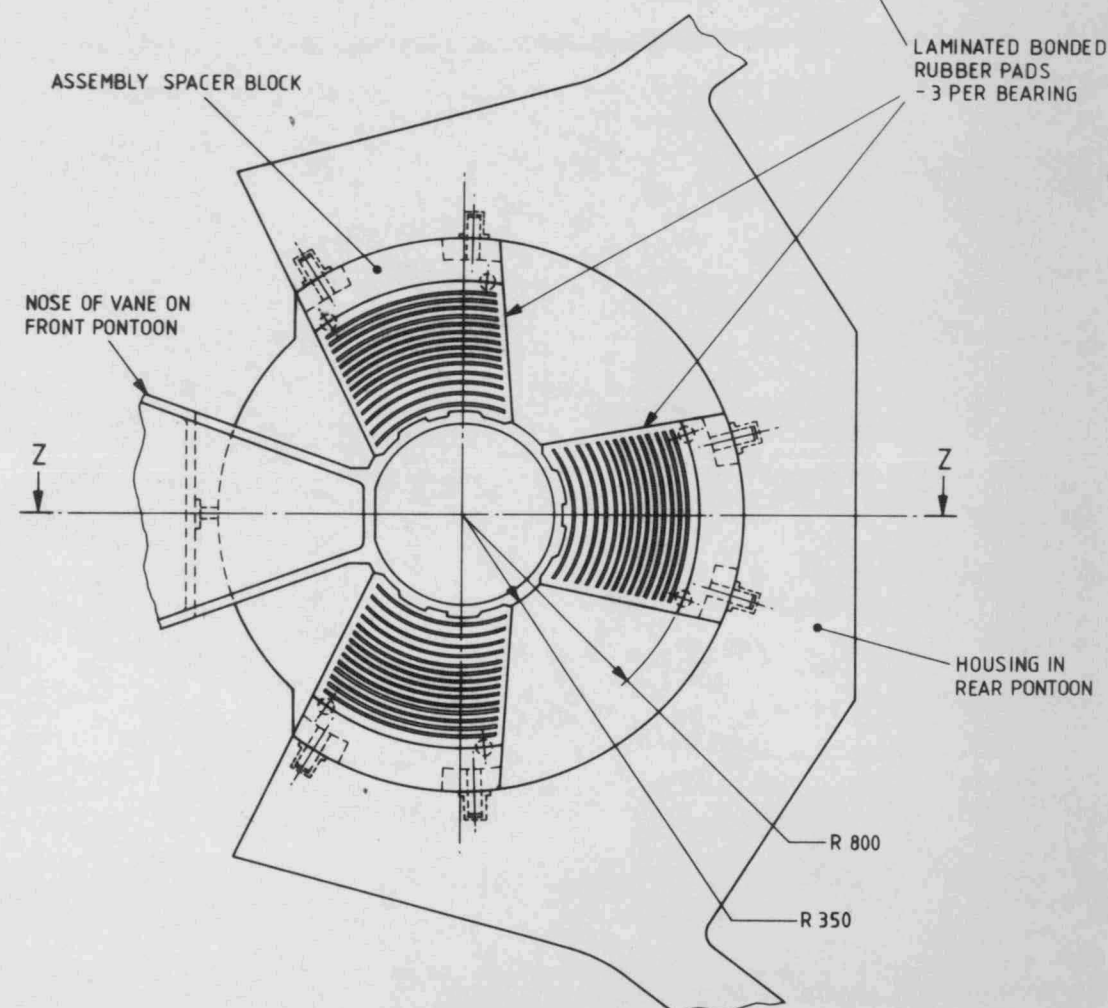




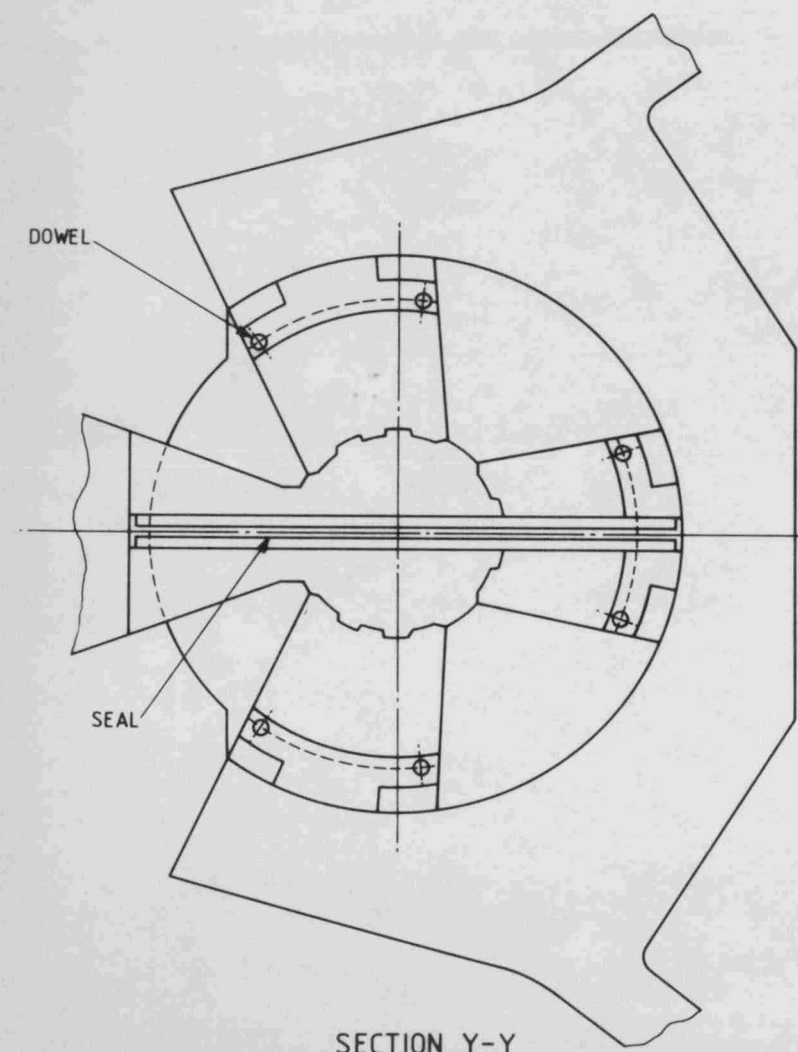
SECTION Z-Z



SECTION THROUGH HINGE BEARING  
WITH FRONT PONTOON AT MAX. ANGLE



SECTION X-X



SECTION Y-Y

NOTES

REV	DATE	BY	DESCRIPTION
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
44			
45			
46			
47			
48			
49			
50			
51			
52			
53			
54			
55			
56			
57			
58			
59			
60			
61			
62			
63			
64			
65			
66			
67			
68			
69			
70			
71			
72			
73			
74			
75			
76			
77			
78			
79			
80			
81			
82			
83			
84			
85			
86			
87			
88			
89			
90			
91			
92			
93			
94			
95			
96			
97			
98			
99			
100			

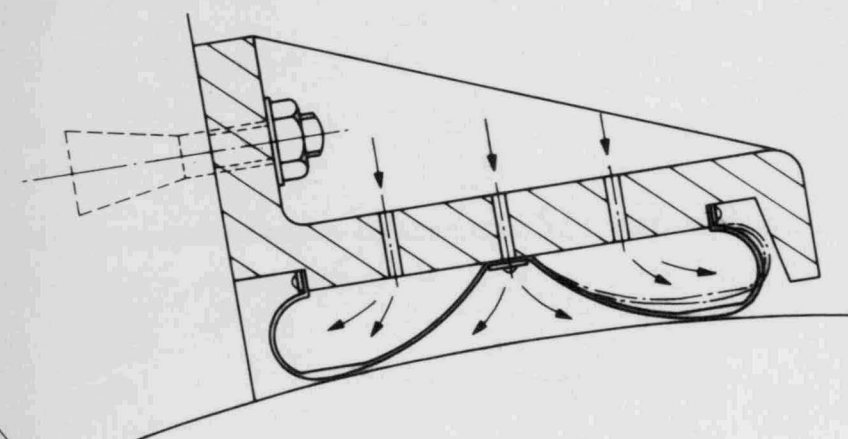
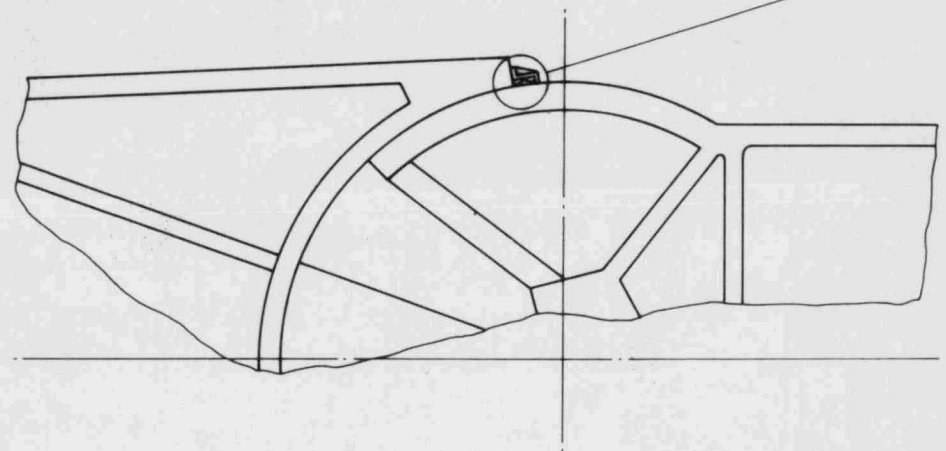
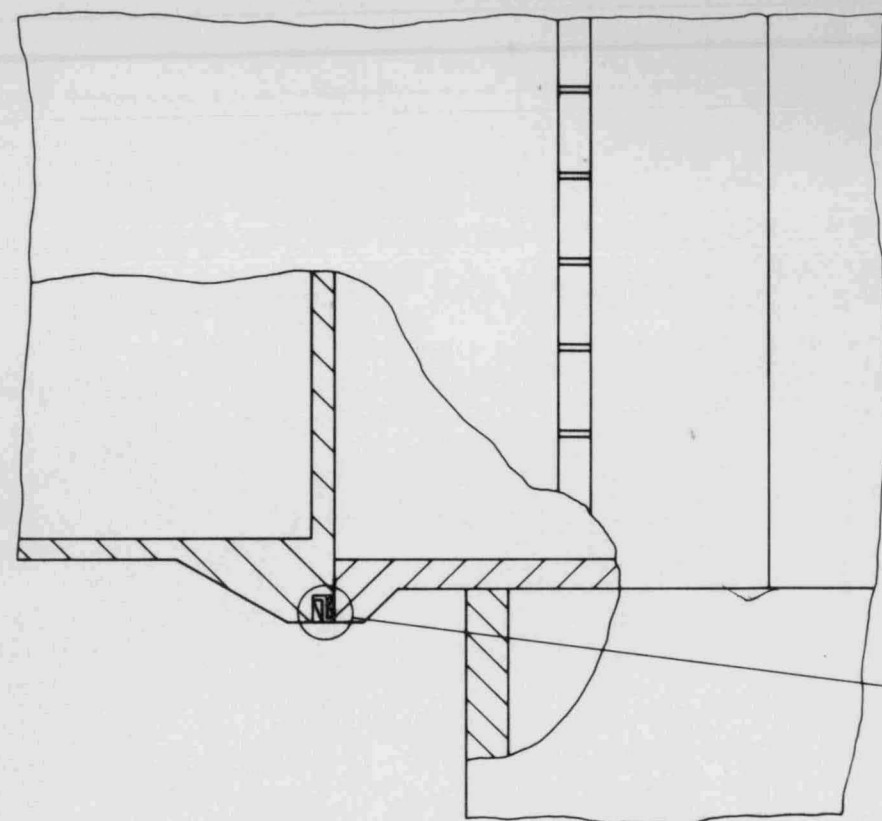
2519-906

3-PAD LAMINATED  
RUBBER HINGE  
BEARING

**WAVEPOWER LIMITED**  
Carlton House Ringwood Road  
Woodlands Southampton SO4 2HT  
Telephone Cadnam (042-127) 3473

LTS  
11-11-79 1:10  
2519-906

NOTES



SCALE 1:2

rev	date	by	description
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
44			
45			
46			
47			
48			
49			
50			
51			
52			
53			
54			
55			
56			
57			
58			
59			
60			
61			
62			
63			
64			
65			
66			
67			
68			
69			
70			
71			
72			
73			
74			
75			
76			
77			
78			
79			
80			
81			
82			
83			
84			
85			
86			
87			
88			
89			
90			
91			
92			
93			
94			
95			
96			
97			
98			
99			
100			

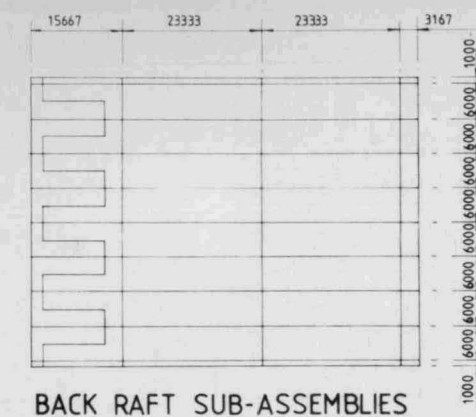
2519-907

VANE PUMP  
OUTER SEAL

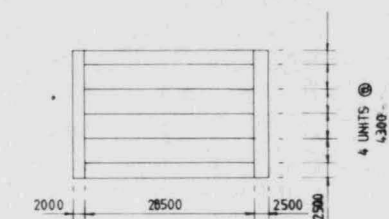
**WAVEPOWER LIMITED**  
 Carlton House Ringwood Road  
 Woodlands Southampton SO4 2HT  
 Telephone Cadnam (042-127) 3473

drawn	checked	approved
LTS		
date	scale	
19-11-79	1:50 & 1:2	
rev		
2519-907		

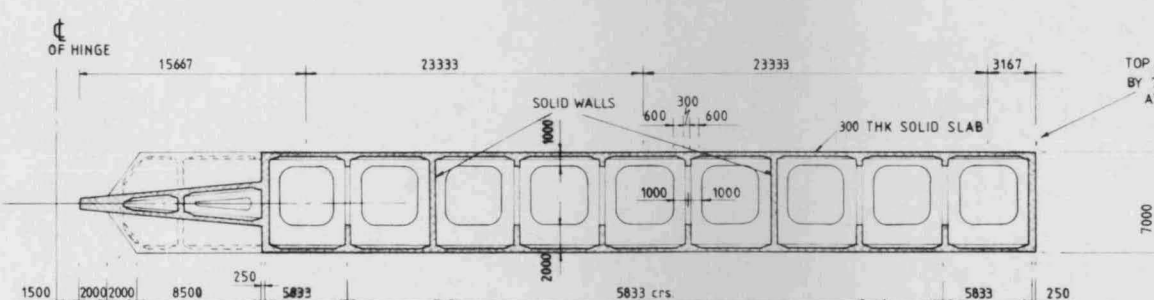
CONCRETE TO BE GRADE 50



## BACK RAFT SUB-ASSEMBLIES

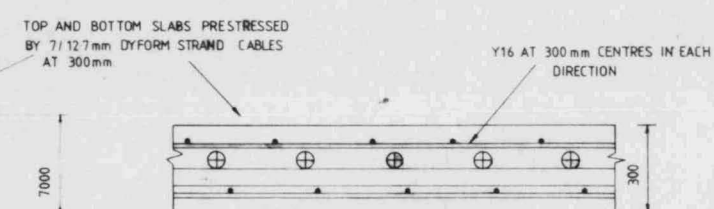


## FRONT RAFT SUB-ASSEMBLIES

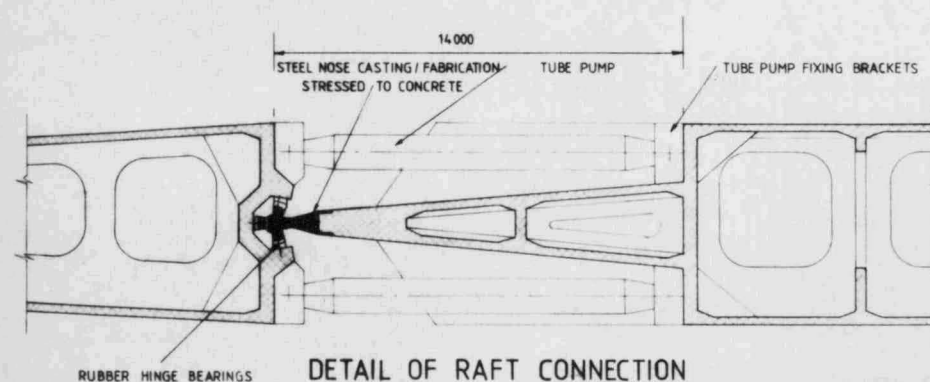


SECTION A-A

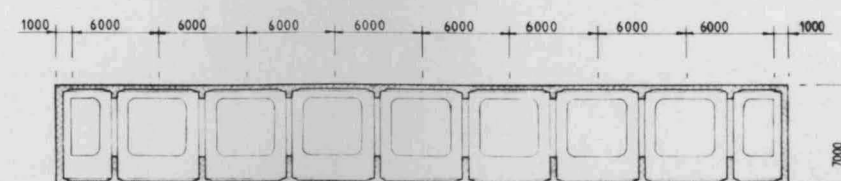
SECTION B-B



SECTION THRO. 300mm SLAB  
SHOWING P/S ARRANGEMENTS



### DETAIL OF RAFT CONNECTION



SECTION C-C

2519-920

## HIGH PRESSURE PUMP SYSTEM

CONCRETE RAFT  
GENERAL  
ARRANGEMENT

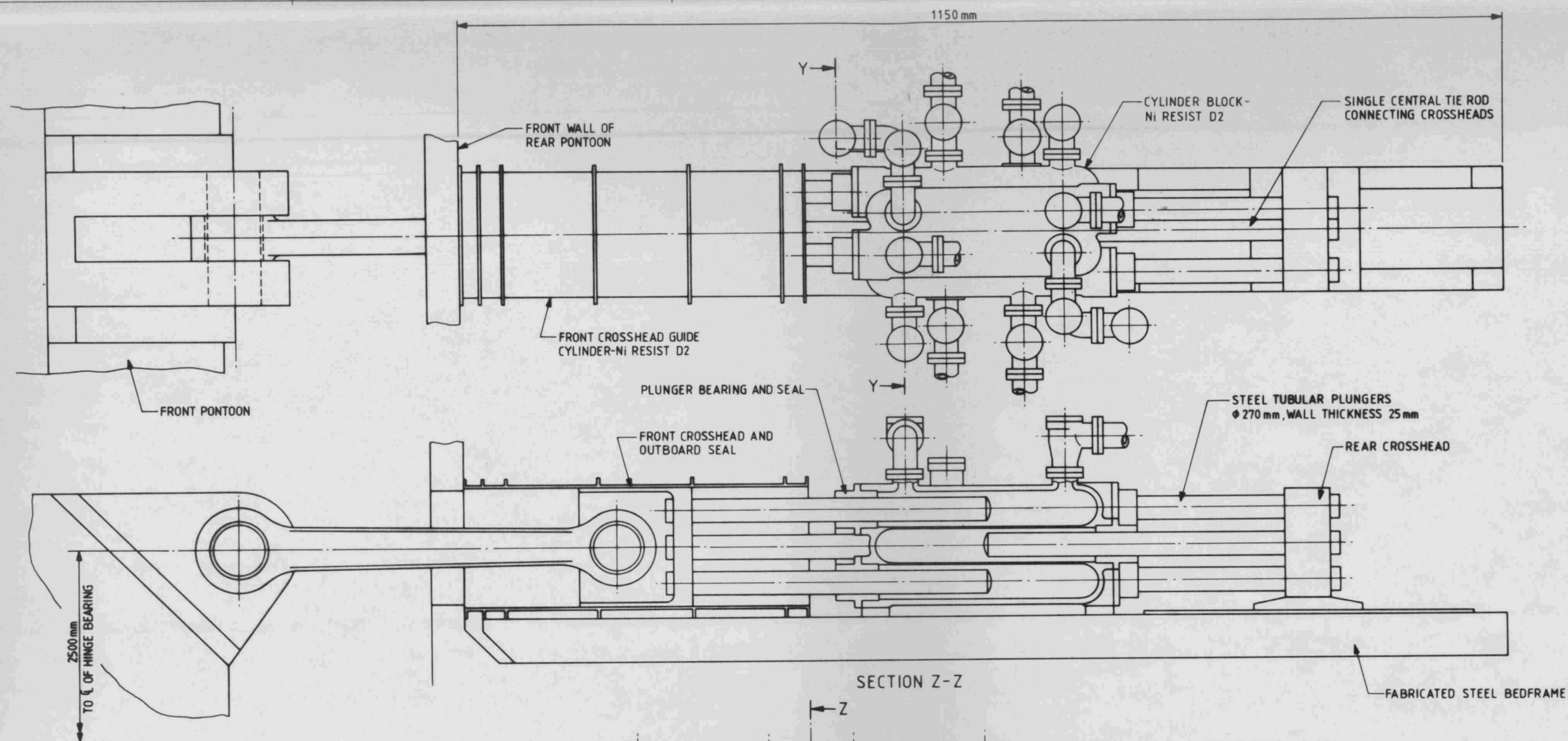
**WAVEPOWER LIMITED**

Carlton House Ringwood Road  
Woodlands Southampton SO4 2HT  
Telephone Cadnam (042-127) 3473

City/State	Cleveland		Admission
R.G.	C	D	
DATE	SIGNED		
AUG '79	1:200 1:100		

2519-920





# NOTES

## PUMP DETAILS

DOUBLE ACTING PLUNGER TYPE  
3 PAIRS OF PLUNGERS

MAX. CYCLIC DISPLACEMENT  
= 0.754 m<sup>3</sup>

MAX. WORKING PRESSURE  
= 15 MN/m<sup>2</sup>

MAX. STROKE = 2140 mm

APPROX. AVERAGE STROKE AT  
RATED POWER = 780 mm

APPROX. OPERATING SPEED  
RANGE AT RATED POWER  
= 5-13 SECS / CYCLE

APPROX. AVERAGE PISTON  
SPEED AT RATED POWER  
AND 11 SECOND CYCLE TIME  
= 0.14 m / SEC.

FLUID - SEAWATER

2519-933

HIGH PRESSURE  
DOUBLE ACTING  
PLUNGER PUMP  
FOR SEAWATER

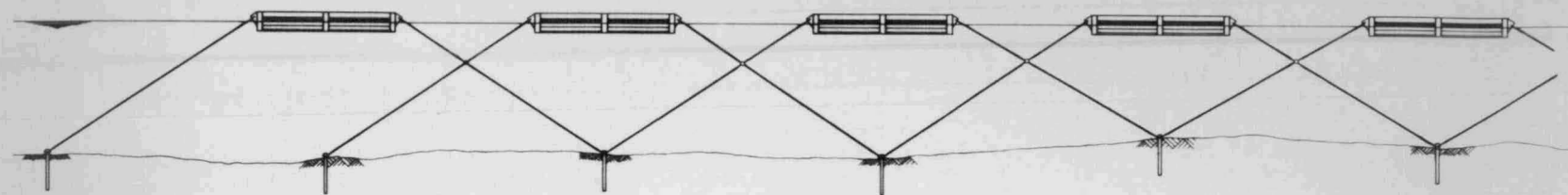
WAVEPOWER LIMITED

Carlton House Ringwood Road  
Woodlands Southampton SO4 2HT  
Telephone Cadnam (042-127) 3473

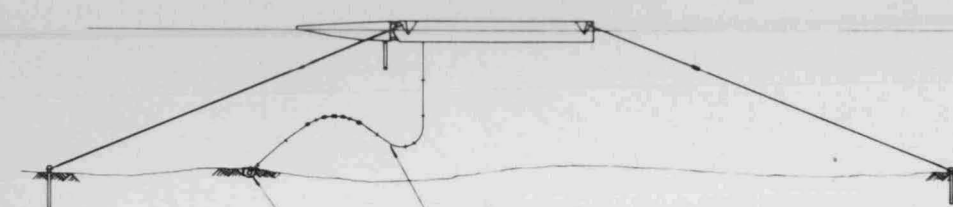
LTS  
13.11.79 1:20 & 1:10

2519-933

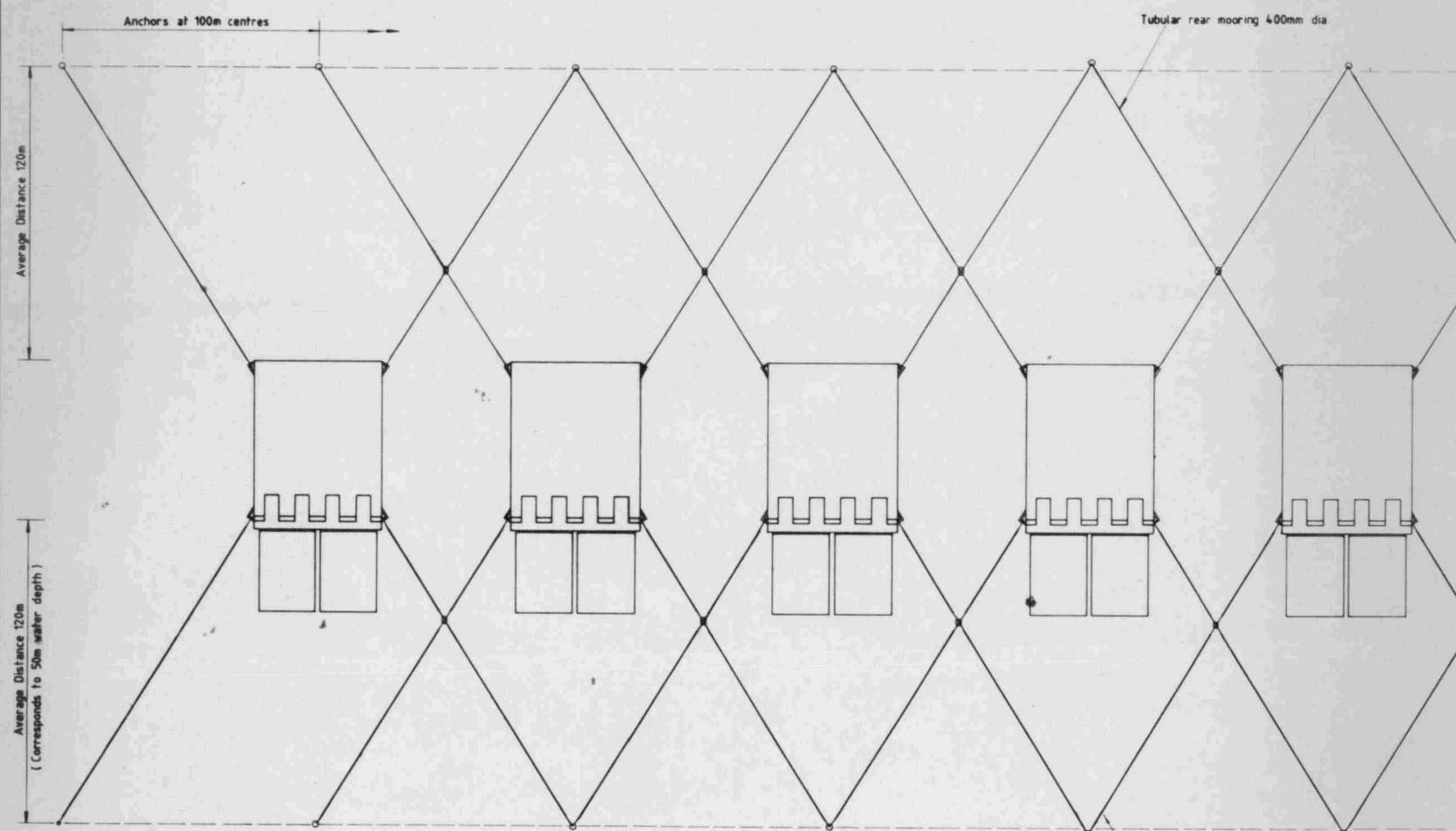




ELEVATION



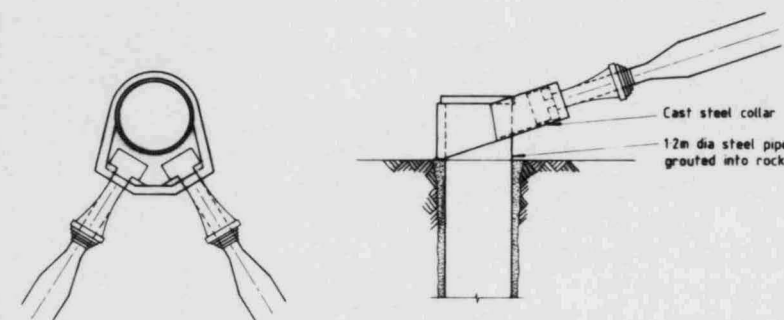
SECTION



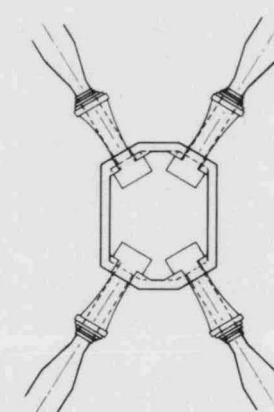
PLAN  
SCALE 1:1000

Tubular rear mooring 400mm dia

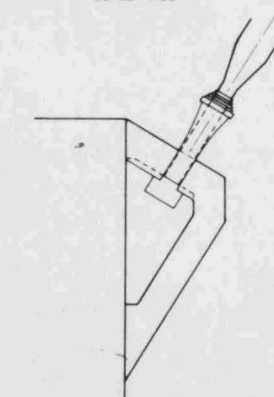
Tubular front mooring 600mm dia



PLAN ELEVATION  
PILE CONNECTION  
SCALE 1:50



CROSS-OVER CONNECTION  
SCALE 1:50



RAFT CONNECTION  
SCALE 1:50

NOTES

NO.	DATE	BY	DESCRIPTION
1			
2			
3			

2519 - 950

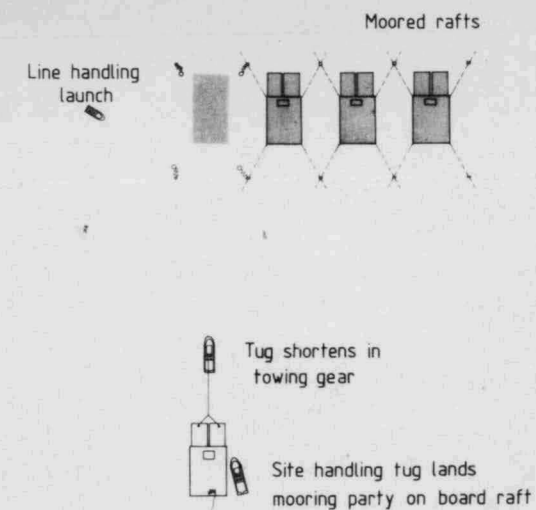
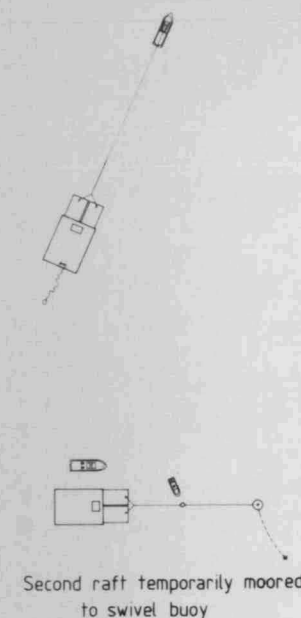
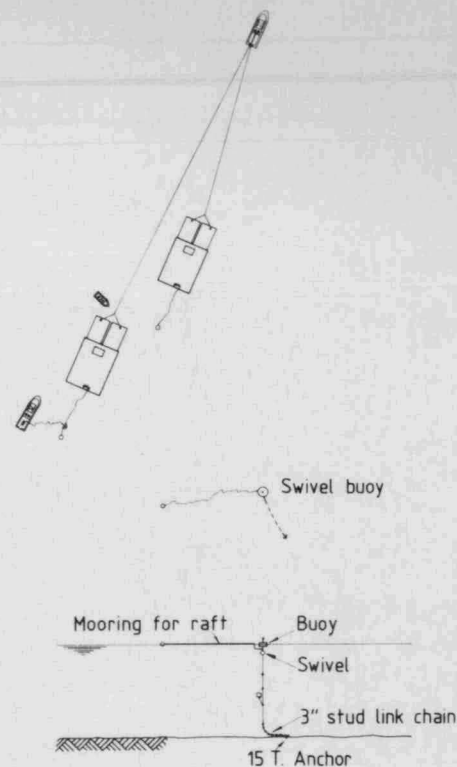
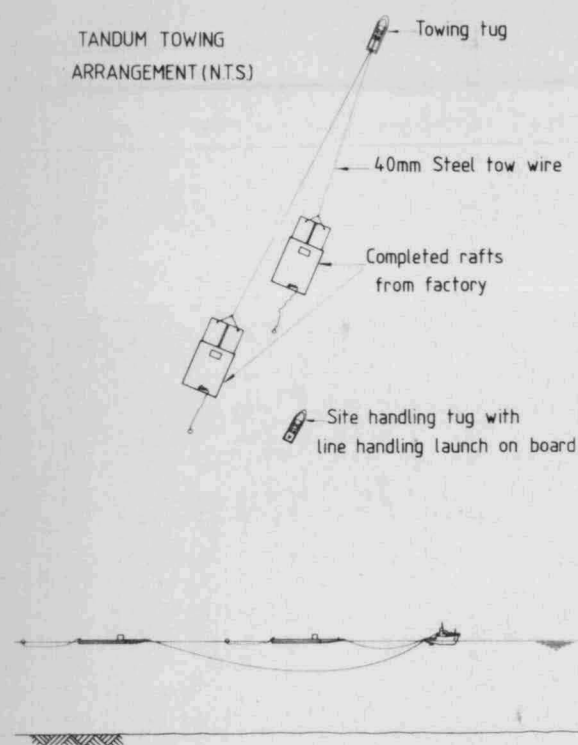
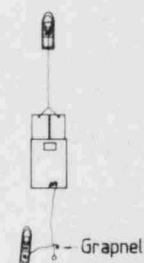
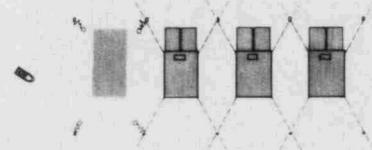
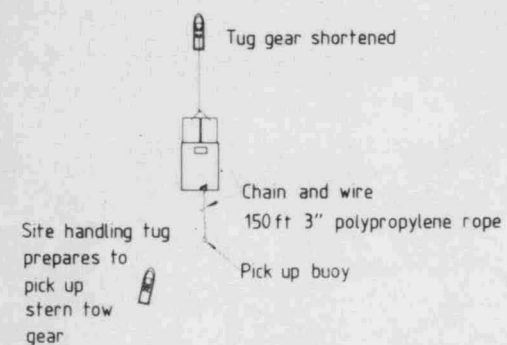
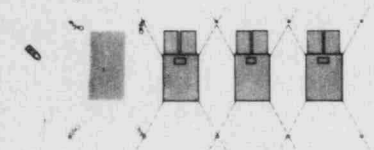
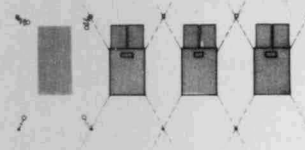
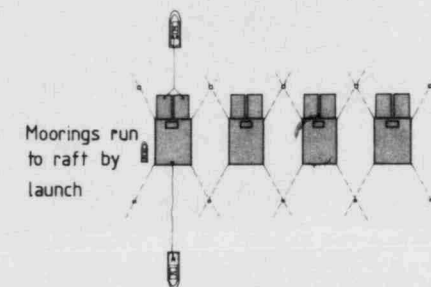
# RAFT MOORING SYSTEM

TYPICAL LAYOUT OF  
ANCHORS IN ROCK  
AND  
CONNECTION DETAILS

**WAVEPOWER LIMITED**  
Carlton House Ringwood Road  
Woodlands Southampton SO4 2HT  
Telephone Cadnam (042-127) 3473

Drawn	Checked	Approved
S.J.C.		
NOV 79	1:1000, 1:50	

2519 - 950

TANDUM TOWING  
ARRANGEMENT (N.T.S.)Mooring buoys  
awaiting raftLaunch  
standing byRaft held in position  
by 2 tugs

2519-951

RAFT MOORING  
PROCEDURE

## WAVEPOWER LIMITED

Carlton House Ringwood Road  
Woodlands Southampton SO4 2HT  
Telephone Cadnam (042-127) 3473

SP  
NOV '79

2519-951



NOTES:-

- 8 Km Raft Chain
- Power Station Position
- Wave Energy Resource Roses
- Sea Bed Contours in Metres



WAVEPOWER LIMITED

OUTER HEBRIDES - PROPOSED LOCATION OF RAFT CHAINS

DRAWING No. 2519.953



30'

15'

59°

45'

30'

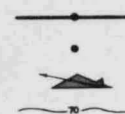
## NOTES :-

8 Km Raft Chain

Power Station Position

Wave Energy Resource Roses

Sea Bed Contours in Metres



N

Sute Skerry

Nun Rock

Cape Wrath

Strathpeith Point

Caithness

Mainland

Hoy

Pentland Firth

Dunnet Head

North Minch

Sutherland

Butt  
of Lewis

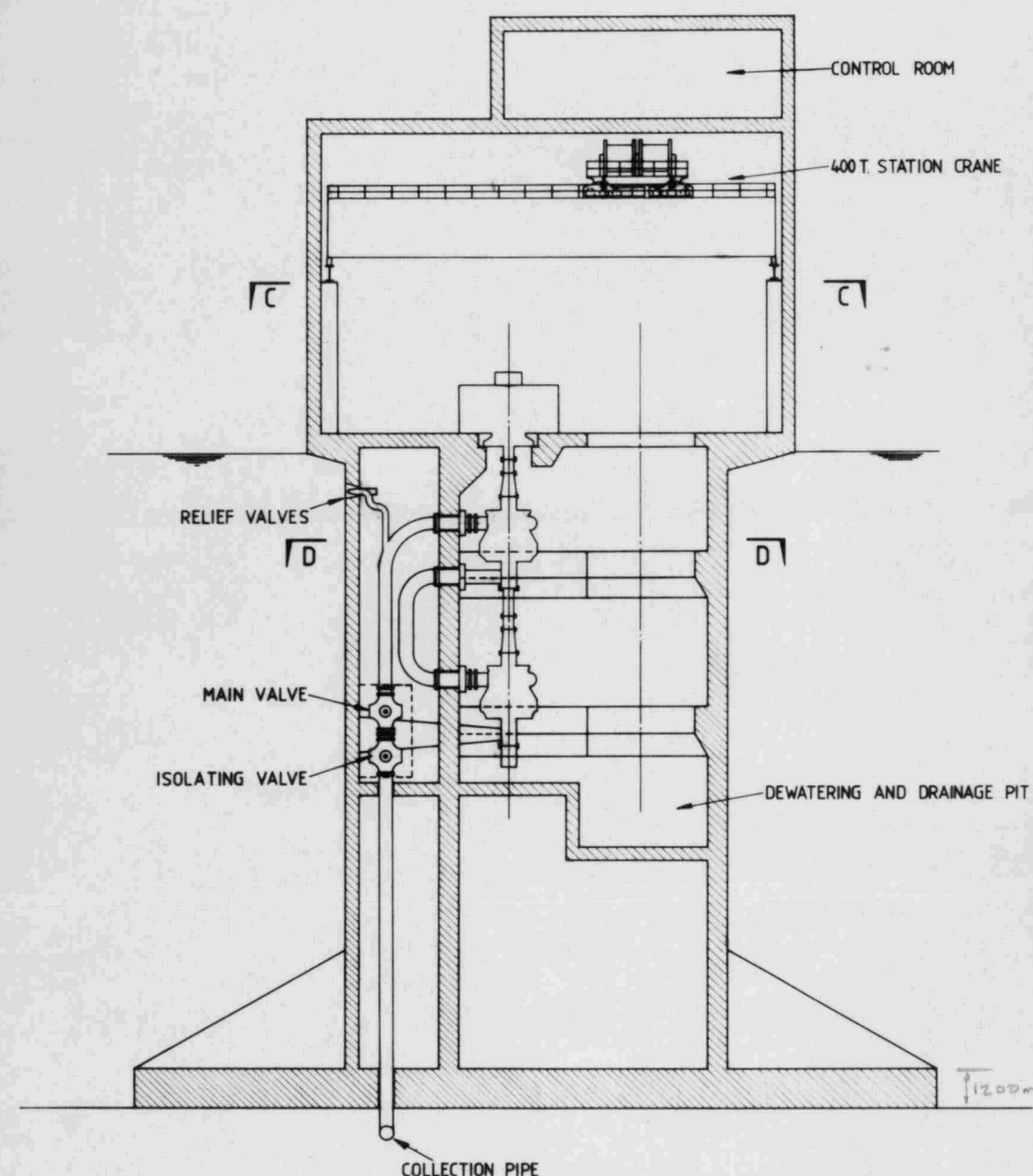
WAVEPOWER LIMITED

NORTH OF SCOTLAND - PROPOSED LOCATION OF RAFT CHAINS

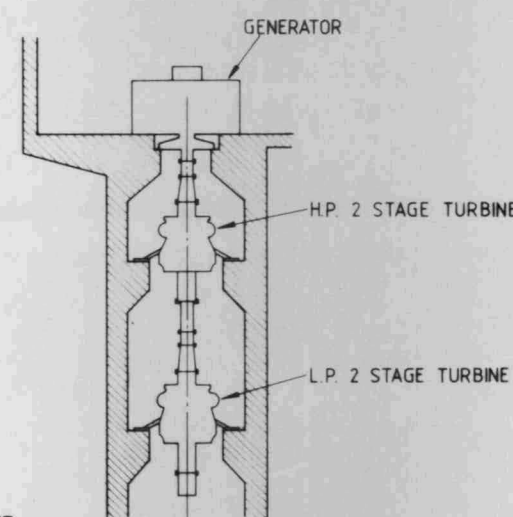
DRAWING No. 2519. 954



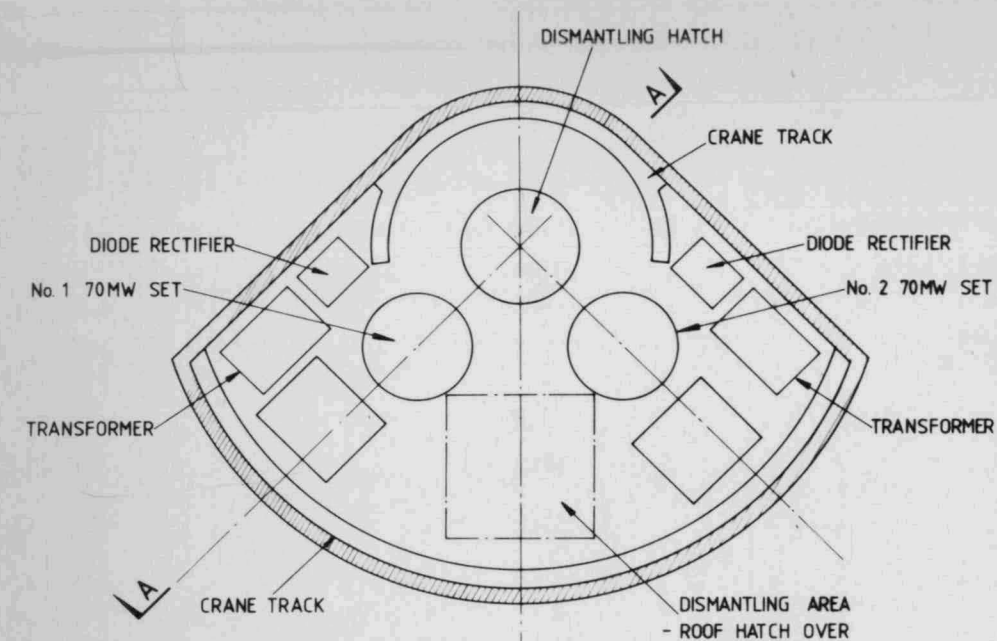
NOTES



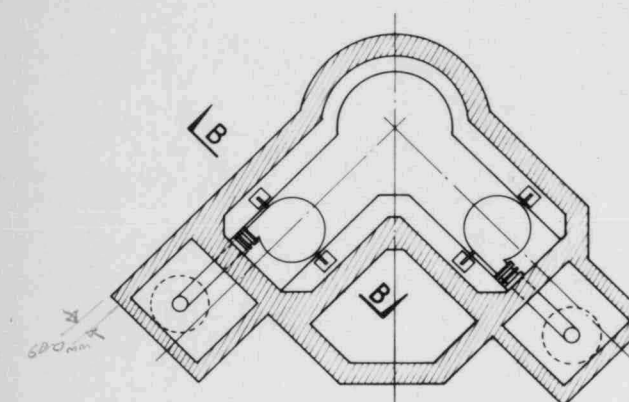
SECTION A-A



SECTION B-B



SECTION A-A  
STATION FLOOR LAYOUT



SECTION D-D

2519-955

LAYOUT OF  
140 MW  
OFFSHORE POWER  
STATION

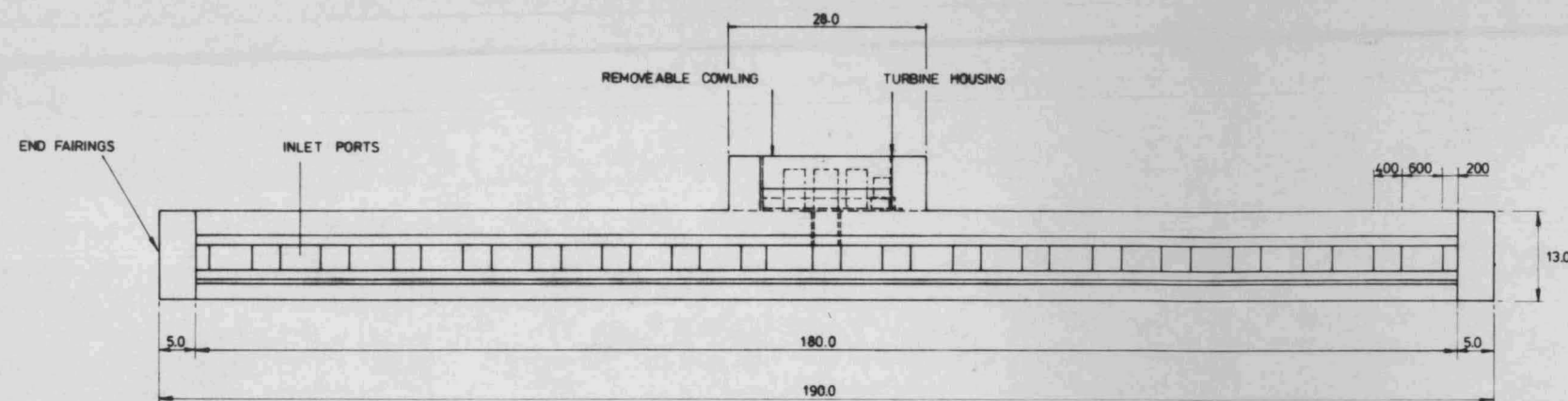
**WAVEPOWER LIMITED**

Carlton House Ringwood Road  
Woodlands Southampton SO4 2HT  
Telephone Cadnam (042-127) 3473

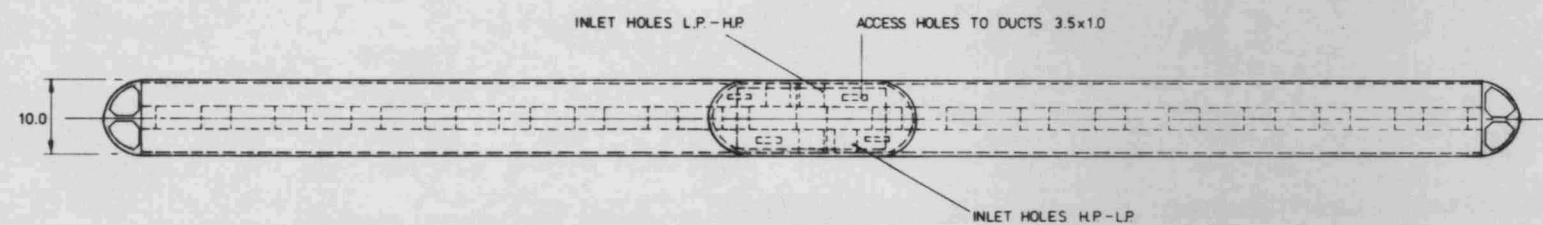
RT C P T approved

Nov 79 1:200

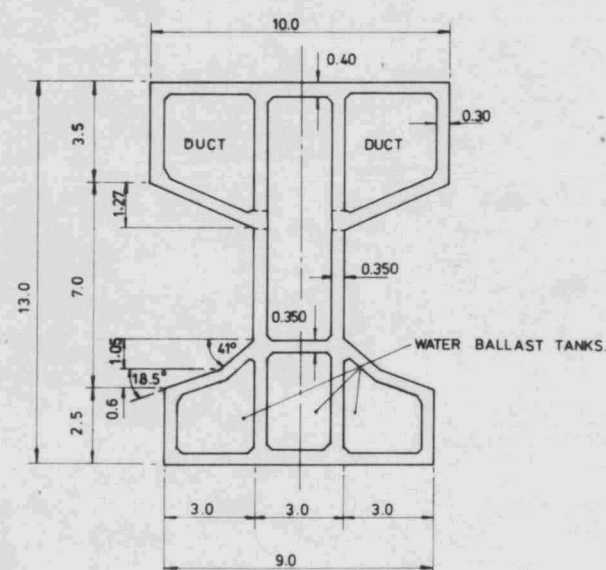
2519-955



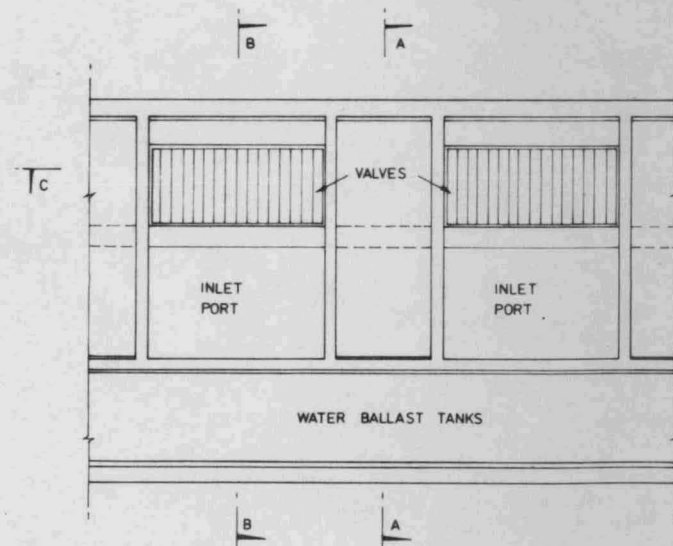
ELEVATION



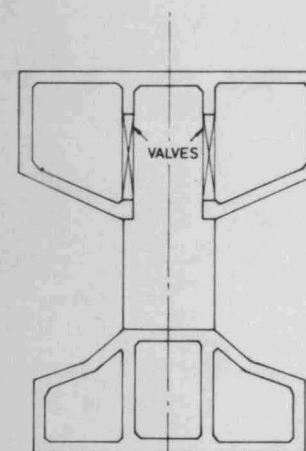
PLAN



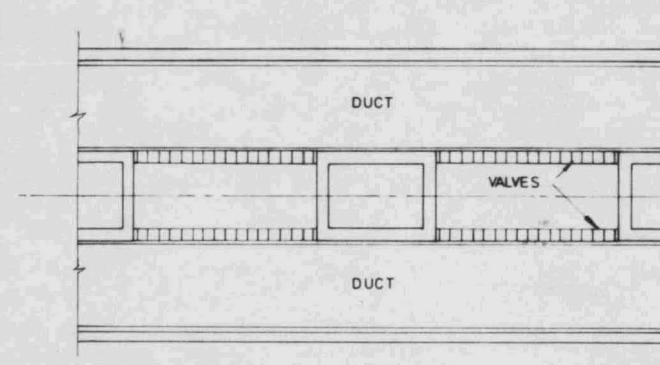
SECTION A-A



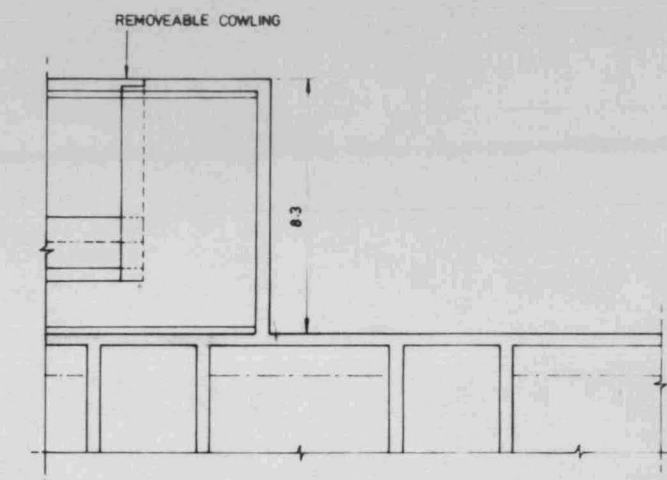
PART LONGITUDINAL SECTION



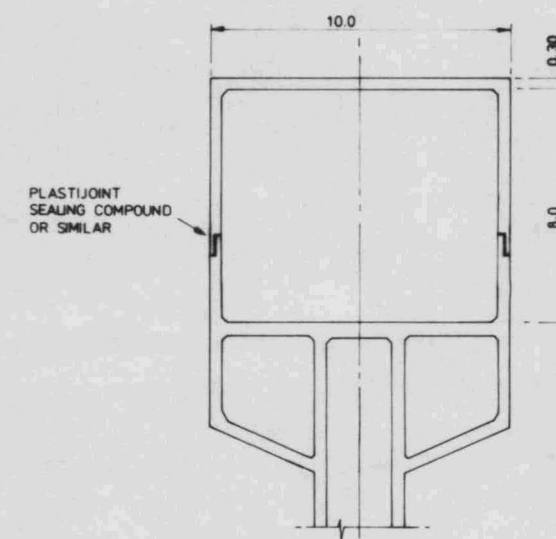
SECTION B-B



SECTION C-C



LONGITUDINAL SECTION  
TURBINE HOUSING (END)



TRANSVERSE SECTION -  
TURBINE HOUSING.

NOTES

HULL STRUCTURE - REINFORCED  
CONCRETE (CLASS 50)  
WITH LONGITUDINAL PRESTRESS

FOR CONSTRUCTION DETAILS  
(TURBINE HOUSING)  
SEE DRG N° 2633/2

A OCT 79 S.C. TURBINE HOUSING & END  
FAIRINGS MODIFIED.

2633/1

A

THE LANCASTER FLEXIBLE  
BAG  
WAVE ENERGY CONVERTER.

GENERAL ARRANGEMENT  
(HULL STRUCTURE)

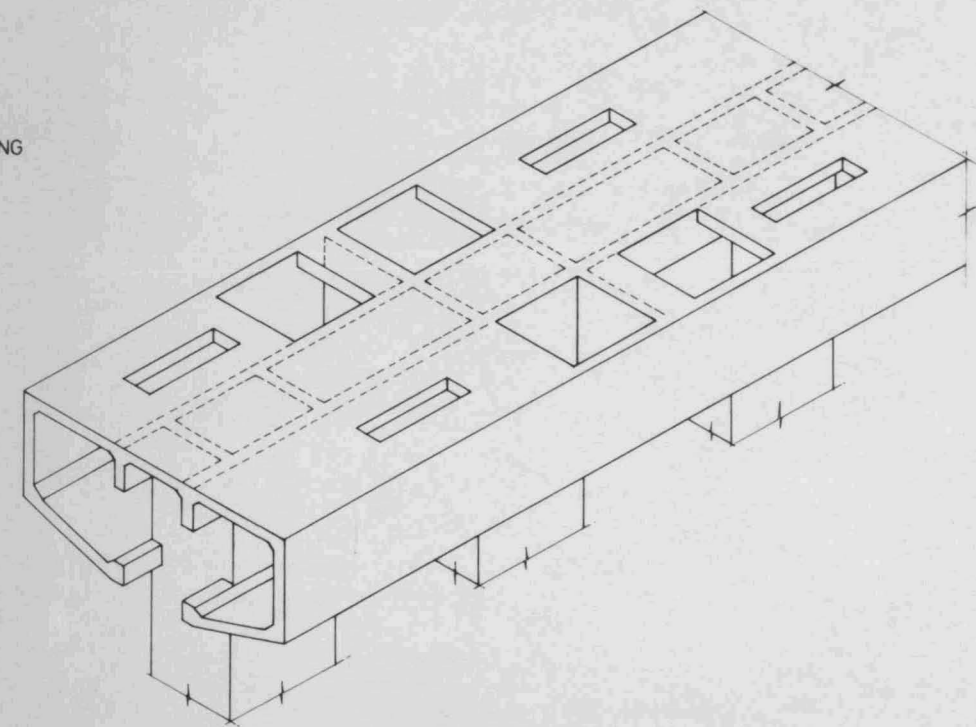
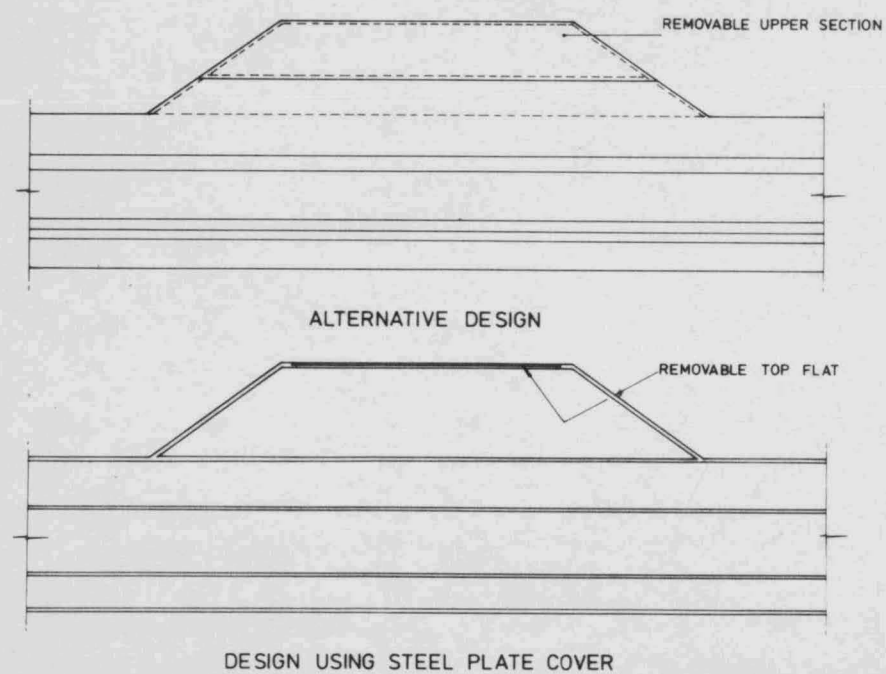
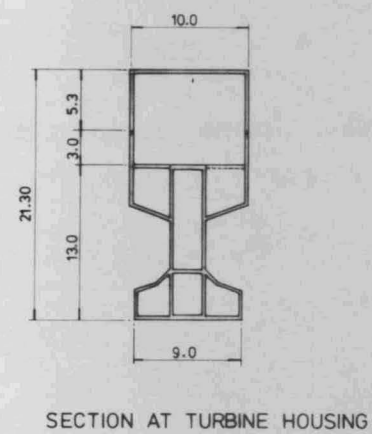
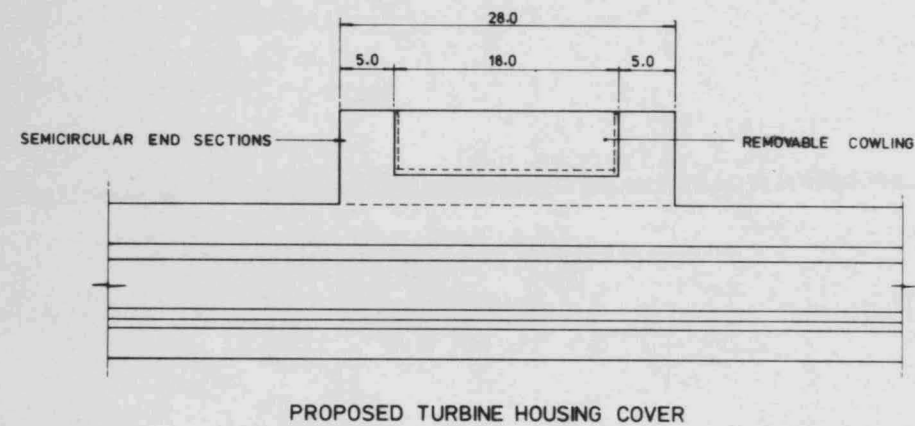
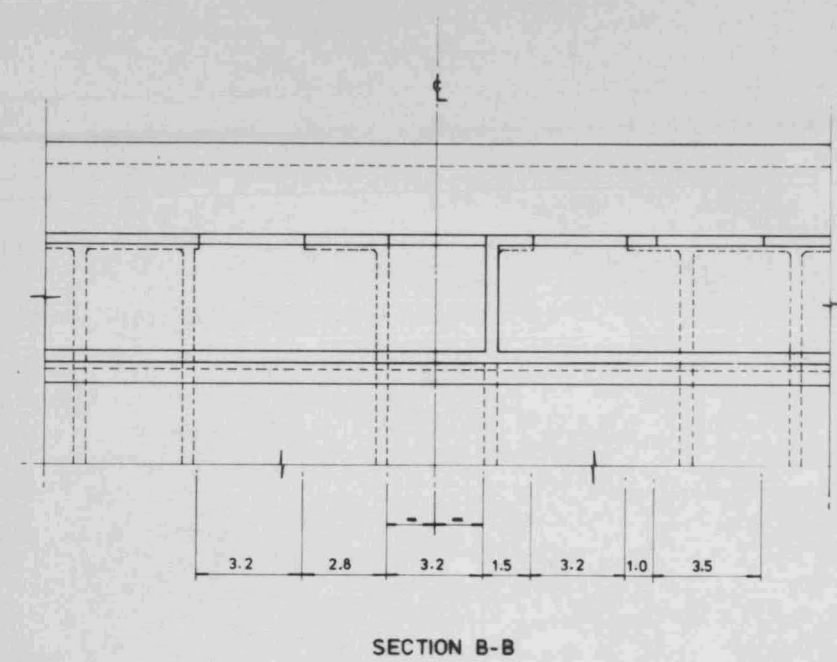
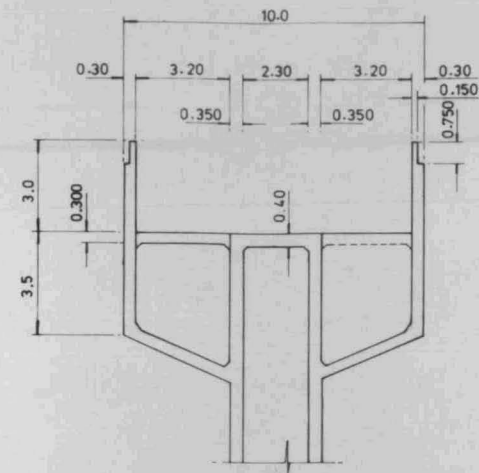
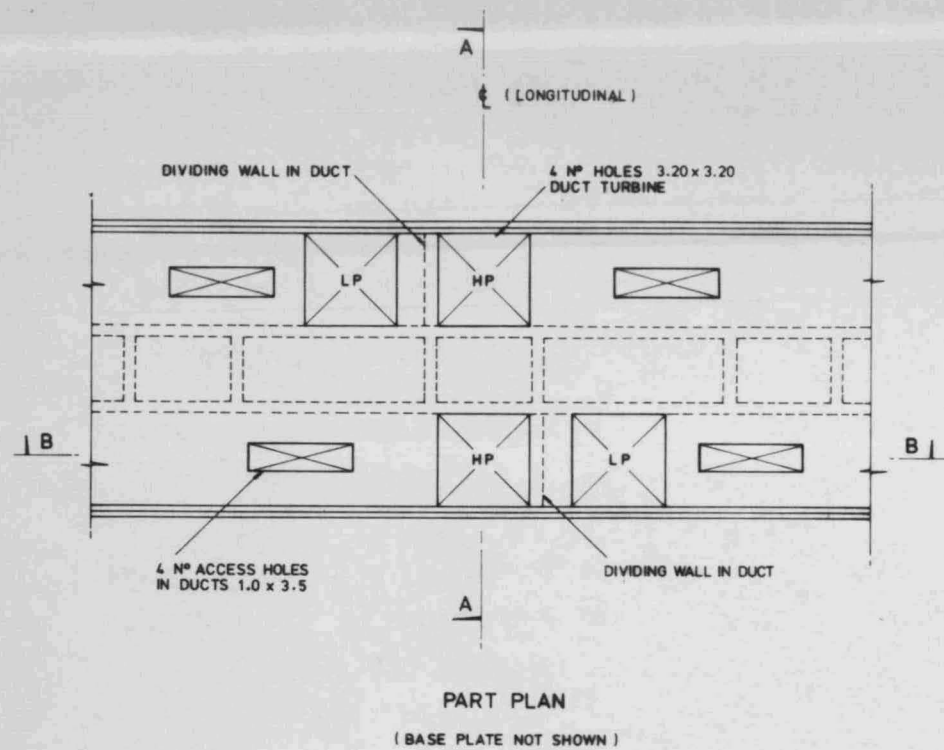
WAVEPOWER LIMITED

Carlton House Ringwood Road  
Woodlands Southampton SO4 2HT  
Telephone Cadnam (042-127) 3468

S.A.C.  
OCT 79  
1:400 1:100

2633/1

A



A DCT79 HEY TURBINE HOUSING MODIFIED

2633/2

A

THE LANCASTER FLEXIBLE  
BAG  
WAVE ENERGY CONVERTER

CONSTRUCTION DETAILS  
(MID SECTION)

WAVEPOWER LIMITED

Carlton House Ringwood Road  
Woodlands Southampton SO4 2HT  
Telephone Cadnam (042-127) 3473

SEP 79 1:25, 1:100

2633/2

A



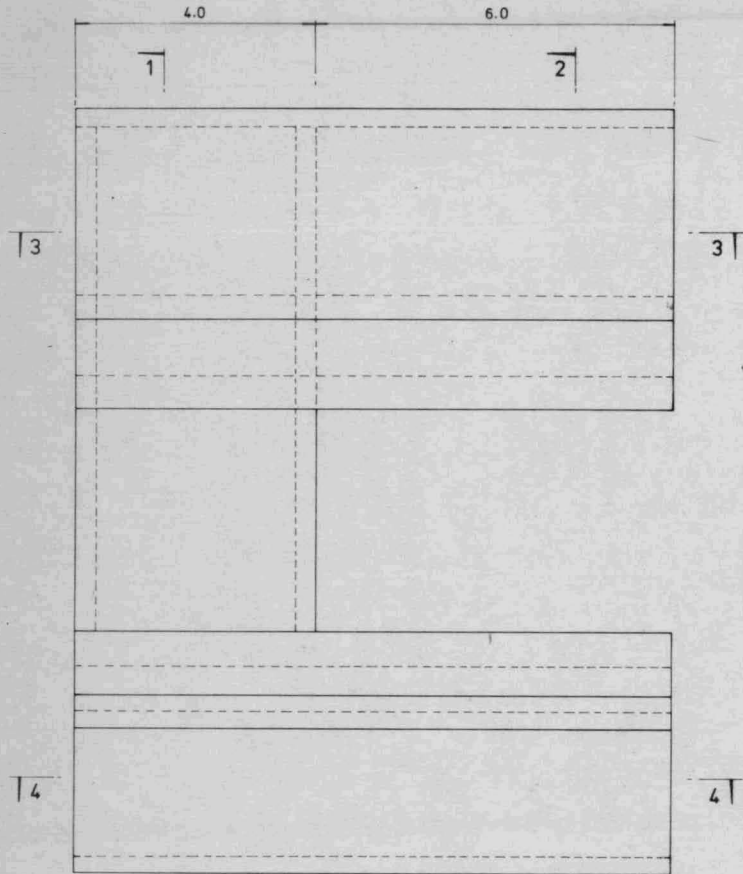
50, 8

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----

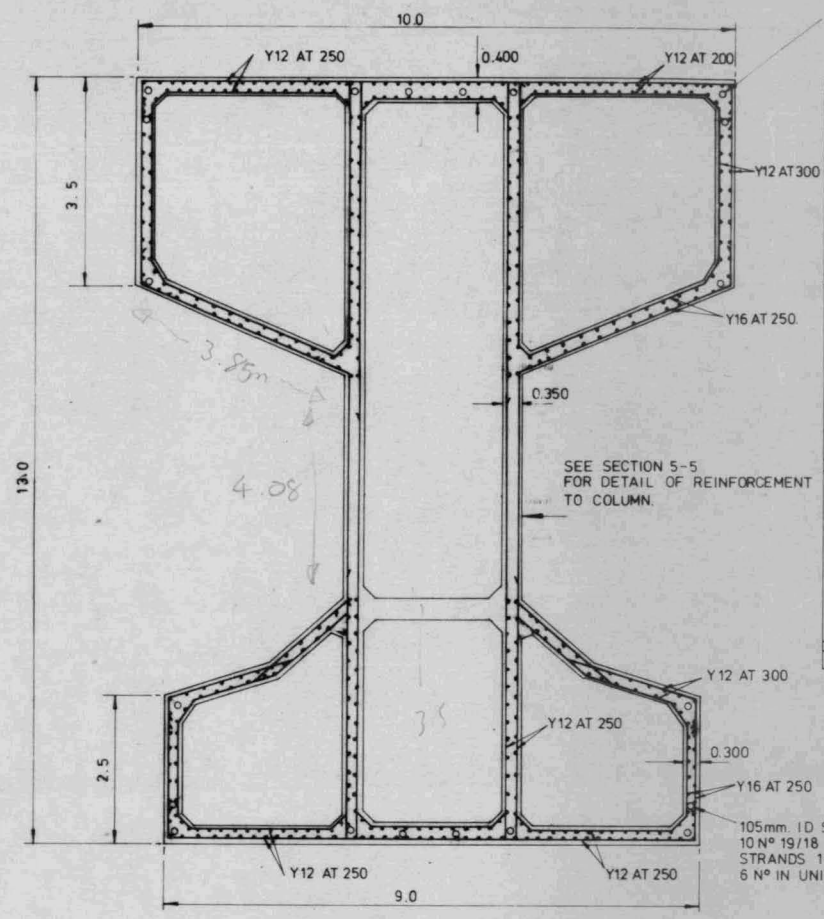
12 5

KEY

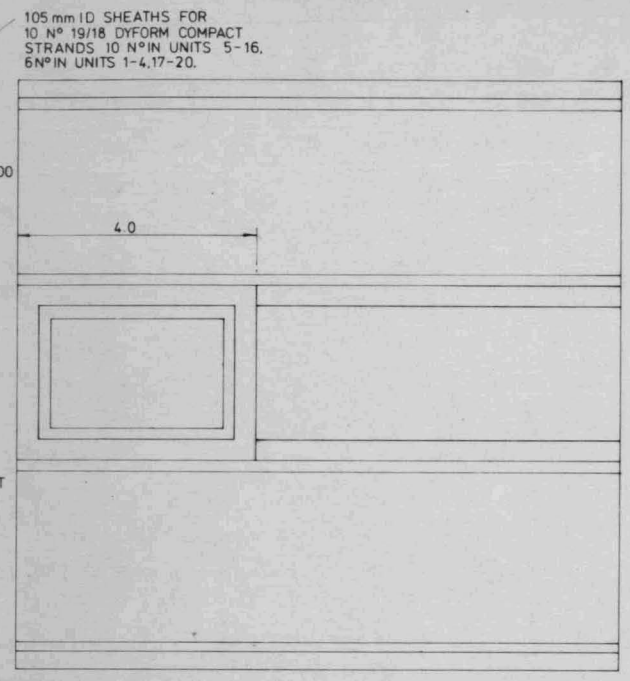
78 mm



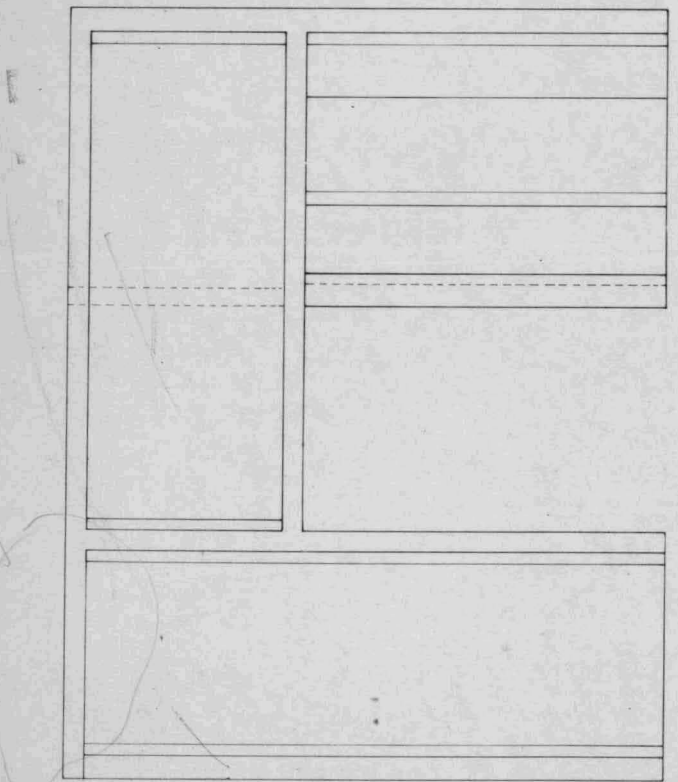
ELEVATION



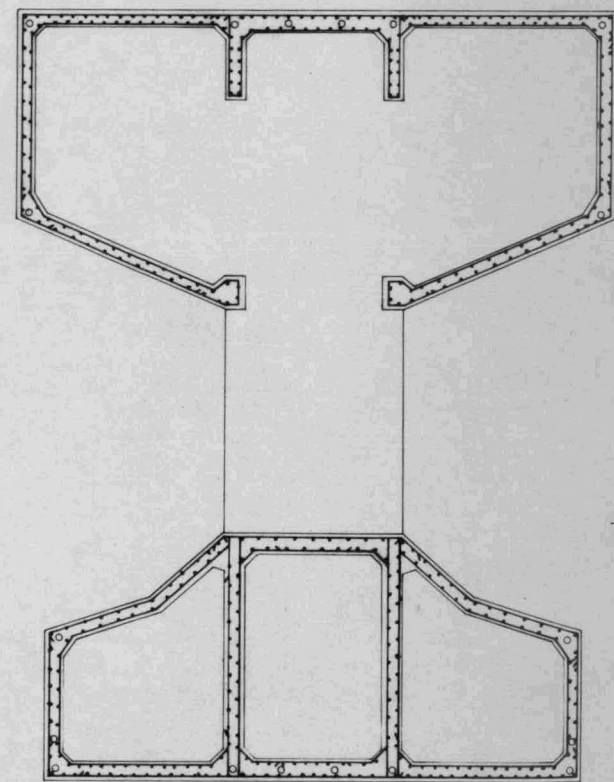
SECTION 1-1



SECTIONAL PLAN DUCTS 3-3



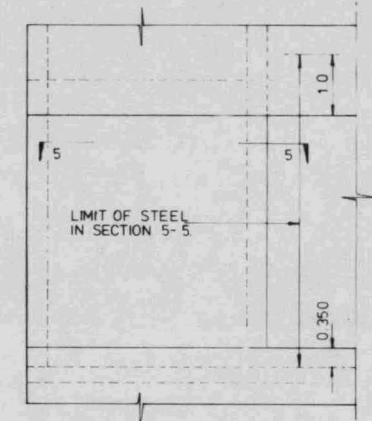
LONGITUDINAL SECTION ON C



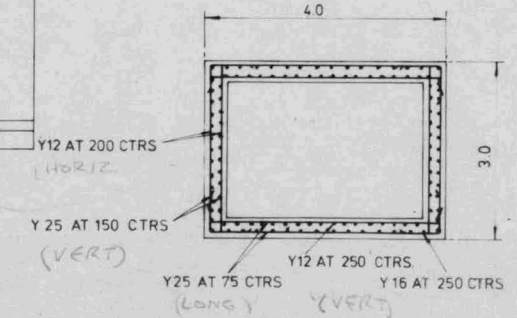
SECTION 2-2



SECTIONAL PLAN BALLAST TANKS 4-4



PART ELEVATION AT COLUMN



SECTION 5-5

NOTES

A OCT 79 HEY GENERAL

2633-3

A

THE LANCASTER FLEXIBLE BAG REINFORCEMENT TO STANDARD UNIT

UNITS 3-7: 14-18 (STANDARD UNITS)

WAVEPOWER LIMITED

Carlton House, Ringwood Road, Woodlands, Southampton, SO4 2HT. Telephone Cadnam 1042-1271 3473

SAC OCT 79 1:50 1:400

2633-3

A



A OCT79/SC TURBINE HOUSING & END  
FAIRINGS MODIFIED

2633 / 4

A

THE LANCASTER FLEXIBLE  
BAG  
WAVE ENERGY CONVERTER  
COUNTER CAST PRECAST  
UNIT CONSTRUCTION

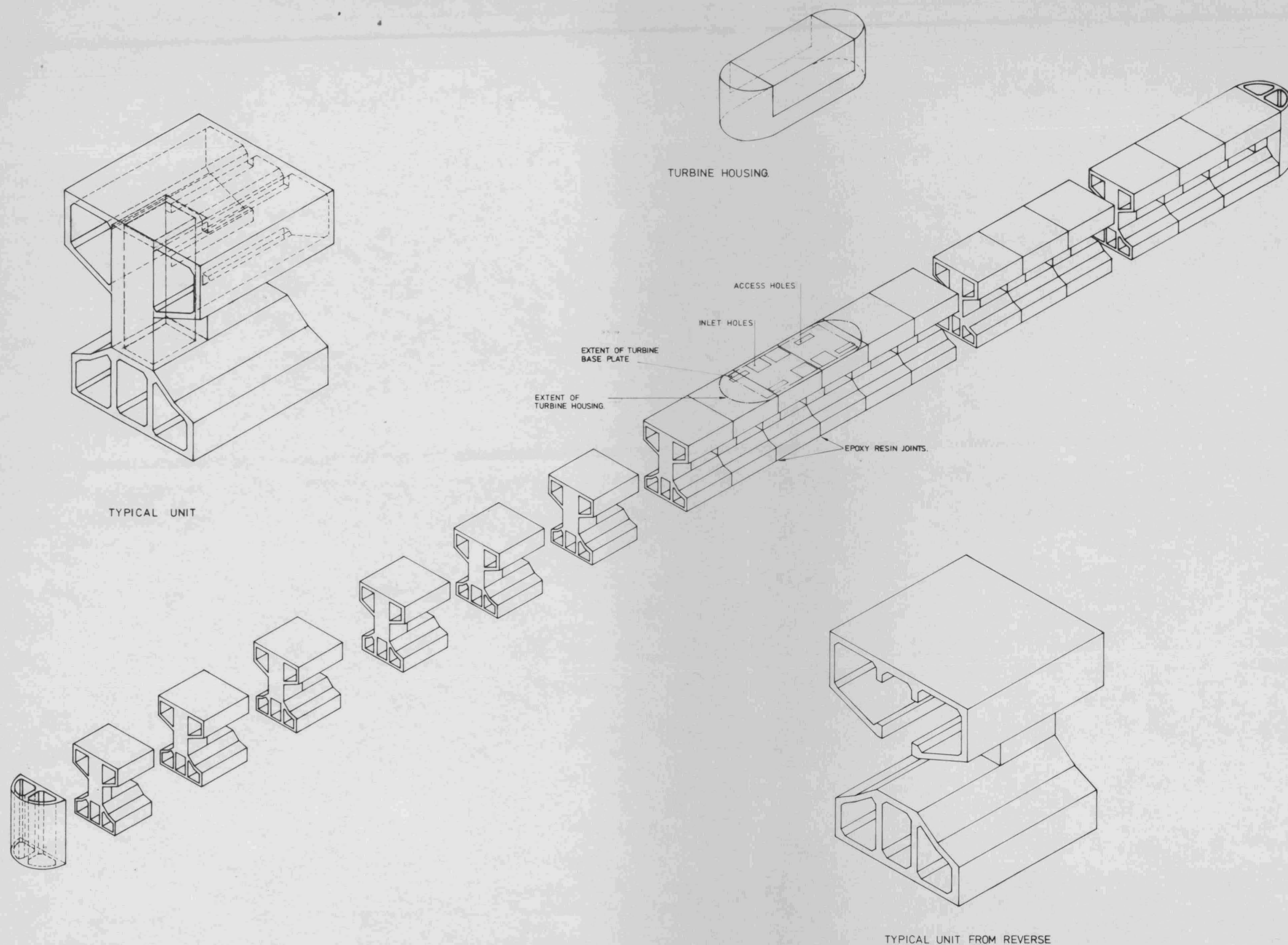
WAVEPOWER LIMITED

Carlton House Ringwood Road  
Woodlands Southampton SO4 2HT  
Telephone Cadnam (042-127) 3473

Drawn: S.A.C. Checked: Approved:  
Date: OCT:79 Scale: 1:1

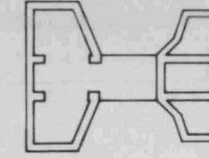
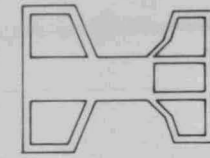
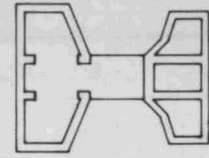
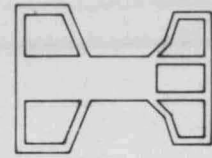
2633 / 4

A

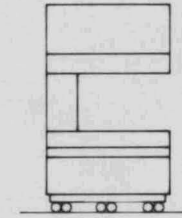
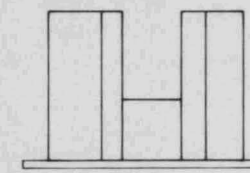
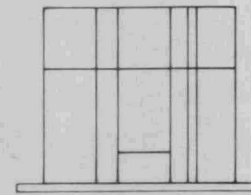
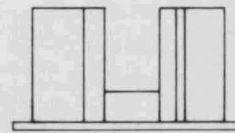
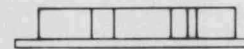
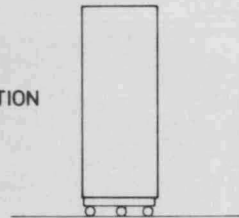


# CASTING BEDS.

PLAN



ELEVATION



## STAGE 1.

1. CAST UNIT 1 ON A TROLLEY.
2. REMOVE INTERNAL & EXTERNAL MOULDS.
3. MOVE UNIT 1 TO CURE & STORE ADJACENT TO ASSEMBLY BAY.
4. REPEAT ABOVE PROCEDURE FOR UNIT 20.

## STAGE 2.

1. CAST FIRST SECTION OF UNIT 2 ON END IN ONE CONTINUOUS OPERATION.

## STAGE 3.

1. COMPLETE CASTING OF UNIT 2 TYING IN REINFORCEMENT WITH THAT PROJECTING FROM FIRST SECTION.

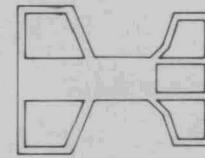
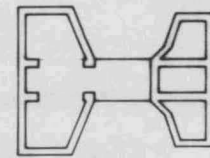
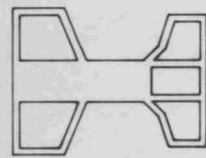
## STAGE 4.

1. COUNTER-CAST THE FIRST PART OF UNIT 3 ON TOP OF UNIT 2 WITH BOND BREAKER IN PLACE BETWEEN UNITS.
2. REMOVE INTERNAL & EXTERNAL MOULDS FROM UNIT 2.

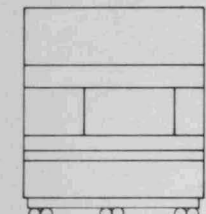
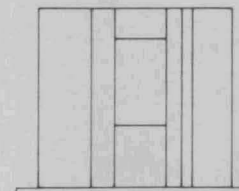
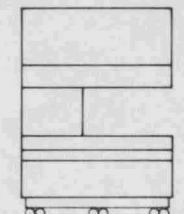
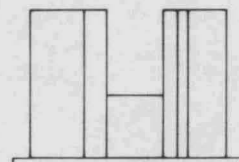
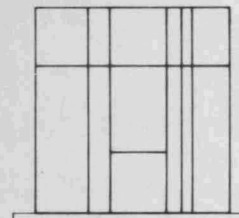
## STAGE 5.

1. LIFT UNIT 3 ONTO A DIFFERENT BED & COMPLETE THE CASTING.
2. LIFT UNIT 2 TO ITS ERECT POSITION ONTO A TROLLEY & STORE ADJACENT TO ASSEMBLY BAY.

PLAN



ELEVATION



## STAGE 6.

1. COUNTER-CAST THE NEXT UNIT ON TOP OF THE LAST WITH BOND BREAKER IN PLACE BETWEEN UNITS.
2. REMOVE INTERNAL & EXTERNAL MOULDS FROM COMPLETED UNIT.

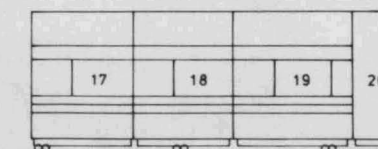
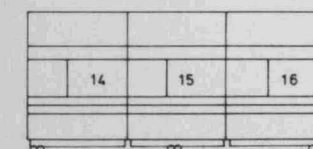
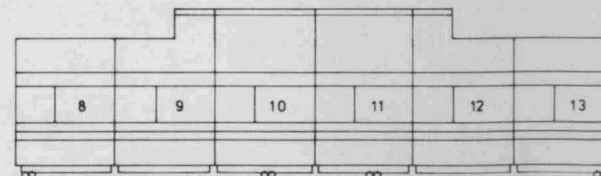
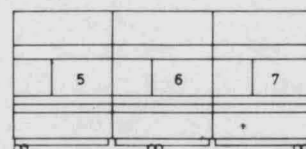
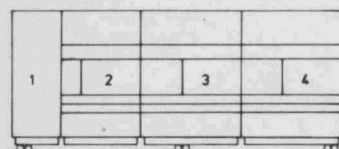
## STAGE 7

1. LIFT DOWN INCOMPLETE UNIT TO A DIFFERENT BED & COMPLETE THE CASTING.
2. LIFT THE PREVIOUSLY COMPLETED UNIT TO ITS ERECT POSITION ONTO A TROLLEY & STORE ADJACENT TO ASSEMBLY BAY.
3. REPEAT STAGE 6 & 7 TO CONSTRUCT UNITS 3-18.

UNITS 8-13 SHOULD BE MODIFIED TO RECEIVE THE TURBINE HOUSING.

## STAGE 8

1. CAST UNIT 19 (WHICH INCLUDES THE ADDITIONAL END SECTION) FOLLOWING THE SAME PROCEDURE AS FOR PREVIOUS UNITS.
2. REMOVE INTERNAL & EXTERNAL MOULDS.
3. LIFT UNIT 19 TO ITS ERECT POSITION ONTO A TROLLEY & STORE ADJACENT TO ASSEMBLY BAY.



## SECTIONS 1

1. CLEAN & PREPARE MATCHING SURFACES READY TO RECEIVE EPOXY BONDING RESIN.
2. ARRANGE THE UNITS IN THE CORRECT ORDER, LEAVING GAPS FOR ACCESS & EPOXY RESIN COATING.
3. POSITION SEGMENTS OF PRESTRESS FOR EACH OF THE 5 SUBSECTIONS.

## 2

4. BRING THE UNITS SUBSECTIONS 3 INTO CLOSE CONTACT. LEVEL & ADJUST EACH UNIT TO ENSURE TIGHT FIT OF GUIDE KEYS.
5. OPEN GAPS FOR APPLICATION OF EPOXY BOND.
6. APPLY EPOXY BOND RESIN TO ALL MATING SURFACES.
7. POST TENSION THE PRESTRESSING CABLES FOR SUBSECTION 3.

## 3

8. CLEAN & PREPARE MATING SURFACE OF SUBSECTIONS 2 & 4.
9. BRING UNITS INTO CLOSE CONTACT & ADJUST AS NECESSARY.
10. OPEN GAPS & APPLY EPOXY BONDING RESIN.
11. POSITION & COUPLE THE PRESTRESSING CABLES TO THOSE IN SUBSECTION 3.
12. POST-TENSION PRESTRESSING CABLES.
13. REPEAT FOR SECTIONS 1 & 5.

## 4

## 5

# NOTES

COUNTER-CASTING MAY NOT BE REQUIRED IF GOOD JOINING BETWEEN UNITS CAN BE ACHIEVED BY OTHER MEANS.

A OCT79/HEY GENERAL

Rev. Date No. Description

2633-5

A

THE LANCASTER FLEXIBLE BAG  
WAVE ENERGY CONVERTER

CONSTRUCTION SEQUENCE

(COUNTER-CAST PRECAST UNITS)

WAVEPOWER LIMITED

Carlton House Ringwood Road  
Woodlands Southampton SO4 2HT  
Telephone Cadnam (042-127) 3473

Drawn SAC

date OCT '79

scale N.T.S.

2633-5.

A

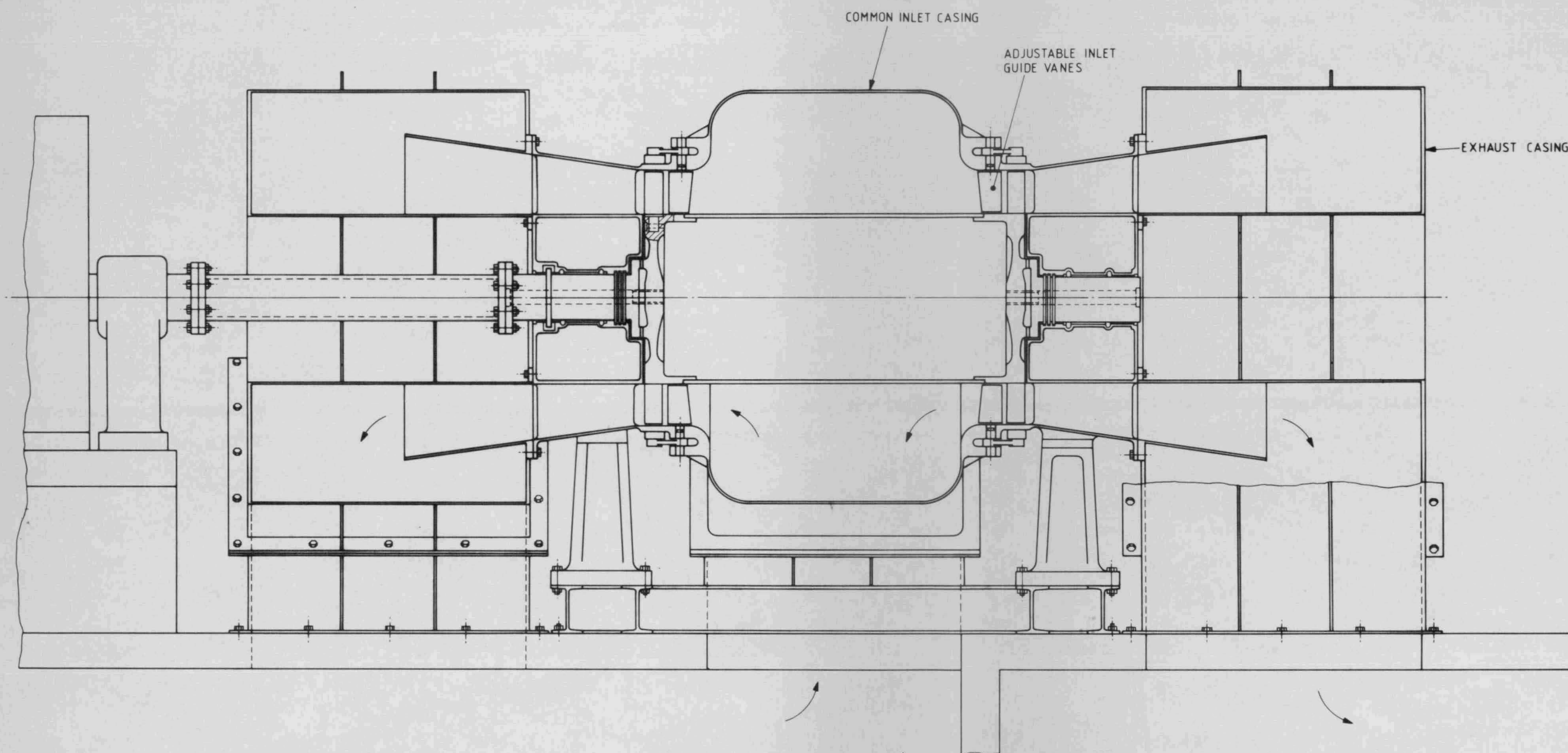
NOTES

TURBINE DETAILS

BLADE TIP DIA. = 2.80m

BLADE ROOT DIA. = 1.725m

TURBINE DESIGN SPEED  
= 850 R.P.M.



LONGITUDINAL SECTION

2633-7

THE LANCASTER  
FLEXIBLE BAG WAVE  
ENERGY CONVERTER

8.2 MW AIR TURBINE

**WAVEPOWER LIMITED**

Carlton House Ringwood Road  
Woodlands Southampton SO4 2HT  
Telephone Cadnam (042-127) 3473

LTS

15.11.79 1:20

2633-7



NOTES

ALTERNATOR DETAILS

RATING :

8.2 MW

9 MVA

850 R.P.M.

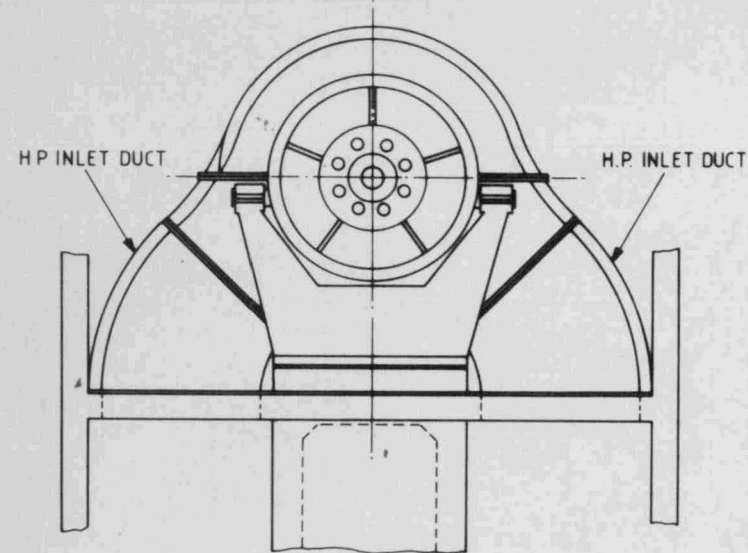
8 POLE

50 Hz

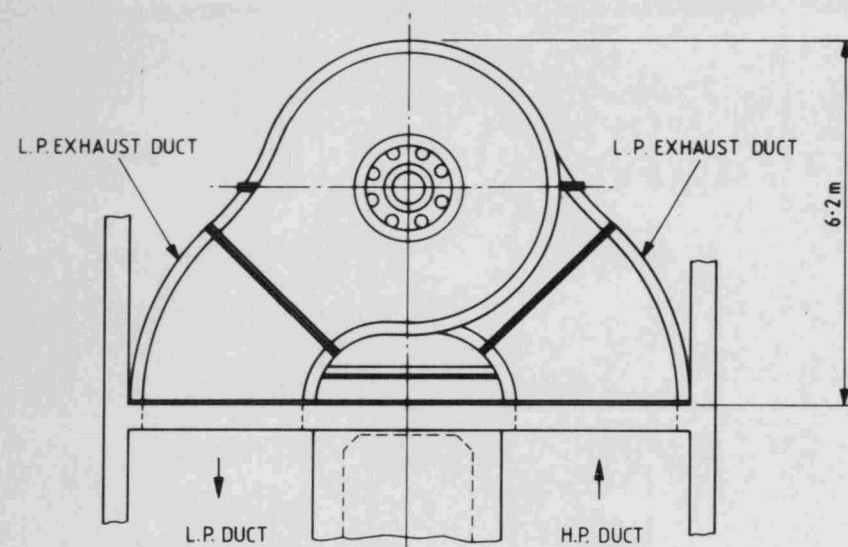
3 PHASE

6.6 - 11kV A.C.

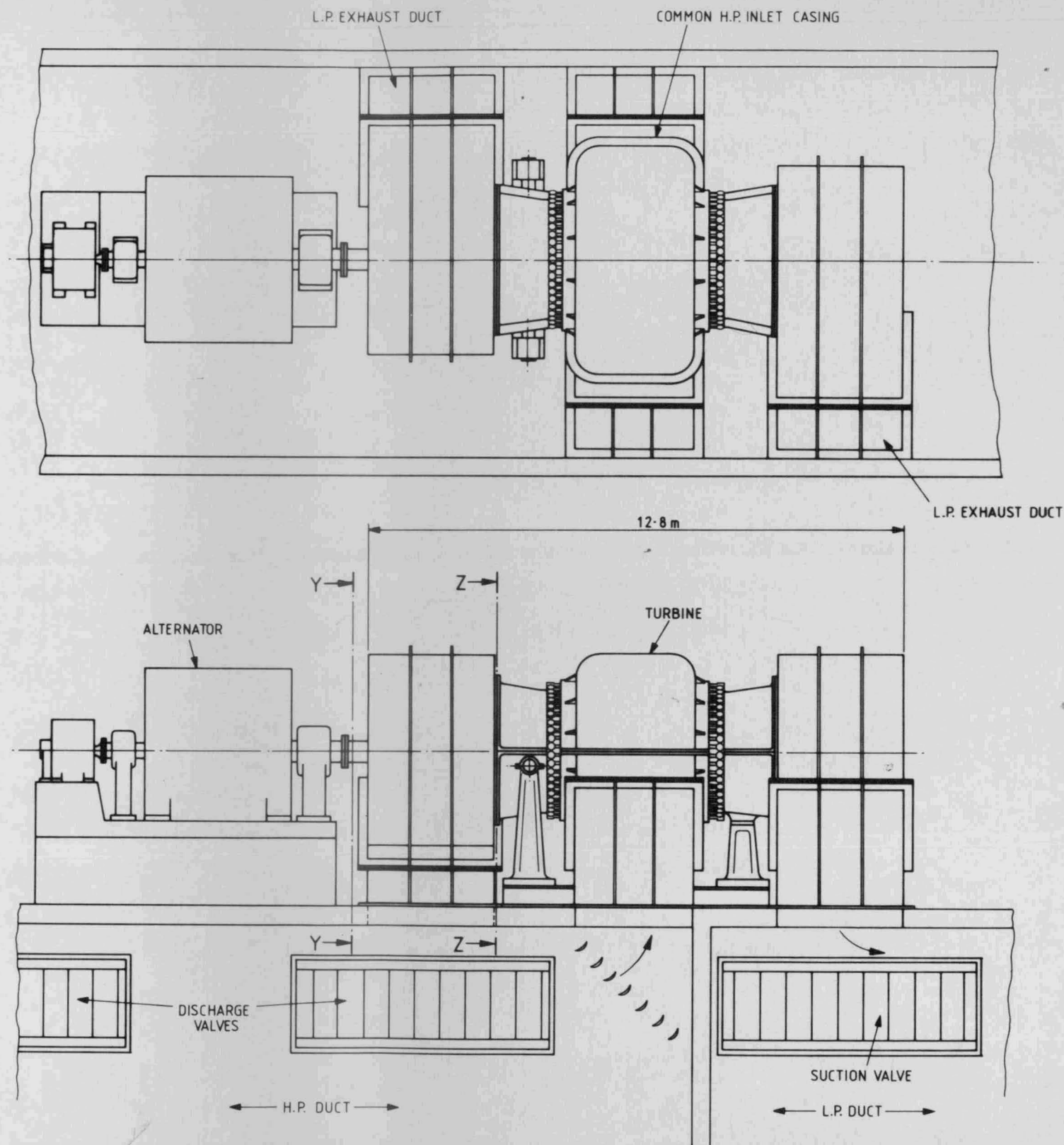
BRUSHLESS EXCITATION



SECTION Z-Z



SECTION Y-Y



2633-8

THE LANCASTER  
FLEXIBLE BAG WAVE  
ENERGY CONVERTER

8.2 MW AIR TURBINE  
AND ALTERNATOR

**WAVEPOWER LIMITED**

Carlton House Ringwood Road  
Woodlands Southampton SO4 2HT  
Telephone Cadnam (042-127) 3473

LTS

22.11.79 1:50

2633-8